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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656]

Competition by roads, waterways, and airways.

(*Continuation*) (1).

Great Britain.

By courtesy of the British Railway Clearing House, we publish hereafter a memorandum of the British Railway Companies showing developments in regard to competition and co-ordination between road and rail during the year 1937.

Legislation.

Road Traffic Act, 1930.

There have been no important alterations or amplifications of the above Act during the year 1937.

As shewn by the following figures, the tendency for small operators to be absorbed by the larger concerns has continued, and this has resulted in a better standard of vehicle and better provision for the comfort of passengers :

At 31st December.	Number of operators owning			Total number of vehicles owned by		
	Up to 49 vehicles. (1)	50 or more vehicles. (2)	Total. (3)	(1)	(2)	(3)
1933	5 814	112	5 926	18 329	27 064	45 393
1934	5 620	115	5 735	17 713	28 082	45 795
1935	5 186	114	5 300	16 976	29 461	46 437
1936	4 870	121	4 991	16 311	31 662	47 973

(1) See *Bulletin*, June, 1934 and subsequent issues.

Tours and excursions.

As the result of an appeal, the Minister of Transport has decided that when passengers are conveyed by road service from one district to a holiday resort in another district, either for one day or a longer period, the operators of such road services are not permitted to convey the passengers on more than one local excursion from the destination resort.

Road and Rail Traffic Act, 1933.

Under the powers vested in the Minister of Transport, regulations have been issued making it obligatory for goods vehicles limited to a speed of 20 miles per hour to carry in a conspicuous position at the rear a disc bearing the number « 20 » in bold characters, and for all trailers to carry a disc bearing the letter « T ».

All newly registered vehicles — passenger and goods — which may be legally driven at a speed exceeding 12 miles per hour must be fitted with a speed indicator that will shew the driver he is exceeding the maximum permissible speed.

From the second Annual Report of the Licensing Authorities, it is evident that the provisions of the Act, particularly those relating to loading, hours of duty and speed limits, are still being disregarded to a serious extent, and this is a matter which is engaging the attention not only of the Authorities themselves, but also of the more prominent members of the haulage industry.

With regard to the number of vehicles on the roads, a comparison of the figures for 1935 to 1937 gives the following results :

	Licences.			(*) Vehicles authorised.			Average number of vehicles per licence.		
	1935	1936	1937	1935	1936	1937	1935	1936	1937
(**) A licences	28 739	28 916	28 888	100 182	102 855	102 749	3.49	3.55	3.52
(**) B »	35 279	34 320	34 589	55 558	54 590	55 216	1.57	1.59	1.60
(**) C »	149 282	161 535	186 734	303 886	329 195	372 487	2.04	2.03	1.99
	213 300	224 771	250 211	459 626	486 640	530 452	2.10	2.16	2.12

Notes.

(*) Including trailers, which are licensed as separate units.

(**) The different classes of licences for goods vehicles are as under :

« *A* » *licences :*

Public carriers — Licence valid for two years.

« *B* » *licences :*

Persons who carry goods in connection with any trade or business of their own and also as public carriers. These licences, which are valid for one year may have attached to them conditions limiting conveyance for hire or reward to :

(a) A defined area or between specified places.

(b) Certain classes of goods only.

(c) Goods of specified persons.

« *C* » *licences :*

Persons who carry goods in connec-

tion with their business only — Licences valid for three years.

« C » licence applications are not opposable. It is difficult to estimate to what extent the increase in these vehicles means greater competition with the Railways. Many « C » licensed vehicles operate within a very restricted area, and some of the increase represents a change-over from horse and carrier bicycle transport.

Appeals.

The following important principles have been laid down by the Appeal Tribunal during the course of the year :

(1) A Licensing Authority should not, when exercising its discretion to grant or refuse an application, have regard to a difference between road and rail rates.

It is no part of a Licensing Authority's duty to make a classification of goods which should go by rail and road respectively.

An applicant for renewal of an « A » licence should satisfy the Licensing Authority : *(a)* that during currency the vehicles have been fully employed; *(b)* as to his gross receipts and tonnage ; *(c)* that there has been no material change in the circumstances relating to the business.

(2) If, during the currency of an « A » or « B » licence, there has been a substantial break in continuity due to the abandonment of the business, need should be proved for the new business on renewal.

(3) Where an « A » licensee has, on a prior application, stated that he intended to provide certain facilities, and upon renewal shows that he has been providing or intends to provide different facilities, he should show a need for the latter.

(4) Wharfingers, forwarding agents and Clearing Houses doing all or part of their work by sub-contractors should, in the absence of special circumstances, continue to use the sub-contractors rather than have vehicles authorised in their own name to do the work.

(5) If an objector proves that suitable transport facilities are in excess of requirements or would be if the licence were granted, although the proof does not give the objector the legal right to have the application dismissed, it would not be in the public interest for the Licensing Authority to exercice his discretion so as to create wasteful competition.

Regulation of road transport wages.

During 1937 the Committee appointed by the Ministers of Labour and Transport examined the position in regard to the regulation of wages and conditions of service of persons employed in connection with the carriage of goods by road. The Committee's recommendations have in general been accepted by the Ministers, and the Government has announced its intention to legislate accordingly without any avoidable delay.

Regulation of road rates.

The Transport Advisory Council, set up by the Act of 1933, has given lengthy consideration to the whole question of coordination of transport, and as a result has submitted a preliminary report dealing with the question of « Service and Rates » in relation to goods traffic borne by rail, canal, road and coastwise shipping. This report, which recommends, inter alia, the establishment of a Tribunal for the regulation of road rates, and deals with the question of voluntary agreements between road and rail interests in regard to rates, is still under consideration by the Minister of Transport.

Finance Act, 1937.

The Finance Bill of 1937 contained a provision to the effect that the unladen weight of a vehicle should be taken to include the weight of any receptacle placed thereon if such receptacle is not removed when goods are loaded into or unloaded therefrom. An amendment, however, was obtained which provides that this should not apply in the case of a receptacle constructed with the object of being removed from or to the vehicle with its contents, and this, in effect, exempts Railway Companies' containers.

New Legislation.

Road Traffic Act, 1937.

This Act gives the Minister of Transport power to extend the currency periods for A, B and C licences for such longer period as he many prescribe.

The Minister has not yet exercised this power.

General increase in railway rates and fares.

During 1937 the Railway Rates Tribunal authorised an increase of 5 % in the railway rates and fares (with certain exceptions) as from 1st October.

Measures taken by the railways themselves to combat road competition.

Electrification.

Further extensions have been made in the electrification of the British Main-Line Railways during the past two years, and the total mileage at the end of 1937 was 1894 electrified track miles, an increase of 310 track miles over 1936. This mileage does not include services solely operated by the London Passenger Transport Board.

High-speed trains.

The introduction of new passenger train services running at a higher speed than the normal express trains between London and important provincial centres which was started some two years ago has proved very popular, and during the past year a number of additional services of this kind have been inaugurated.

In some cases standard steam locomotives and coaches have been utilised, but in others streamlined locomotives and trains have been employed.

These special trains are painted a distinctive colour, and special attention paid to the interior fittings; restaurant cars are provided.

The seating capacity varies somewhat but is approximately 200 first and third class seats.

On certain of the trains a supplementary fare is payable varying up to 10 % of the single fare, but this extra charge has not affected the popularity of the trains which are extremely well filled.

Diesel traction.

A number of diesel locomotives for shunting purposes is in service, and there has been some limited use of diesel traction in self-contained rail motor cars on local services for the conveyance of passenger and parcels traffic.

Agreed charges.

The Road and Rail Traffic Act of 193 empowered the British Railway Companies to enter into agreements, with the sanction of the Railway Rates Tribunal for the conveyance of merchandise at agreed charges. (Reference to this arrangement was made in the Report for the year 1934) (*). In the first in

(*) See *Bulletin of the Railway Congress* May 1935, p. 485.

stance, the traders themselves took the initiative in asking for an « agreed charge » to be made. At the present moment, however, the Railway Companies are bringing these facilities to the notice of large traders as it is found that the saving in clerical labour is appreciated by the traders, and it has helped the Railway Companies to regain a certain amount of traffic from the road.

At the end of 1937 there were 607 agreed charges in operation approved by the Railway Rates Tribunal, as compared with 367 at December, 1936.

In addition, at the end of 1937, 88 agreed charge offers had been accepted by traders and were awaiting the approval of the Tribunal.

The agreed charges in operation at the end of September, 1937, altogether accounted for 3.3 % of the total revenue from parcels and goods train traffic.

Demountable tanks and road/rail trailers for conveyance of liquids in bulk.

An examination of the question of the transport of liquids in bulk has shown that the Railways are carrying a progressively decreasing tonnage, and as industrial development is moving towards bulk conveyance the Railway Companies recently decided to undertake the provision of tank equipment where the Traders are not prepared to provide their own equipment.

Such equipment will be hired at a fixed sum per annum over a period of years under written agreement between both parties, i.e. on a contract basis.

Two distinct types of equipment have been evolved :

(1) Demountable tanks (without wheels) which can be craned at each end of the journey on to road motor vehicles and are conveyed on ordinary rail wagons.

(2) Road-rail tanks (with road wheels) which are run on to a specially fitted rail chassis.

An indication of the varied nature of the liquids carried is set out below :

Liquid oxygen.	Glucose.
Printing ink.	Edible oils.
Vinegar.	Condensed milk.

Shock-absorbing wagons.

As the outcome of a long series of experiments a special open wagon has been designed with a « floating » body. Shock-absorbing mechanism has been interposed between the chassis and the body with the result that when any shock is imparted to the vehicle, either by reason of an impact or « snatching » on the draw-bar (the 3-link coupling is in general use in Great Britain for the coupling of freight-train vehicles) the vibrations reaching the load are greatly reduced. The buffer and draw-bar springing also has been improved with the object of further reducing transit oscillations.

This type of vehicle, which is still in the experimental stage, will be particularly suitable for the conveyance of fragile traffics in full loads, viz., sanitary pipes, pottery, glass, etc.

Low-temperature transport.

Extensive experiments have been and are being carried out with the conveyance of refrigerated foodstuffs and other perishable commodities. Large numbers of insulated vans and insulated road/rail containers have been built, and it is with these vehicles that controlled-temperature

transport has been developed, and further experiments are being made.

The commodities which are at present being carried in refrigerated vehicles include confectionery, fresh, chilled and frozen meat, wet, frozen and dry fish, rabbits, cooked and preserved meats, milk and cream, soft fruit, and other highly perishable foodstuffs; also cut flowers, bulbs, etc.

Additions to the British Railways' stock o freight vehicles fitted with an automati air-operated brake.

The following particulars indicate th increase in the number of wagons fitte with an automatic air-operated brak (excluding mineral wagons and brak vans) for the years 1931 to 1936 inclu sive :

Number of wagons (excluding mineral wagons and brake vans) fitted with an automatic air-operated brake.						Percentage increase, 1936 over 1931.
1931	1932	1933	1934	1935	1936	
46 221	49 827	53 548	60 253	71 755	80 388	74 %

Co-operation between rail and road transport.

Agricultural Act, 1937.
Land-fertility scheme.

In 1937, the British Government introduced a scheme to promote an increase in the fertility of the land by defraying one half of the cost of lime and one quarter of the cost of basic slag in the form of a subsidy to the farmers.

So far as the transport industry is co cerned, the scheme will tend to result i an increase in traffic, and in order avoid uneconomic competition the Rai way Companies and the British Road F deration have come to an amicable a rangment under which their respecti rates are communicated to each oth with an understanding that, subject certain reservations, such rates will n be decreased without consultation.

[656.234]

Tickets,

by LIONEL WIENER,
Professor at the University of Brussels.

INTRODUCTION.

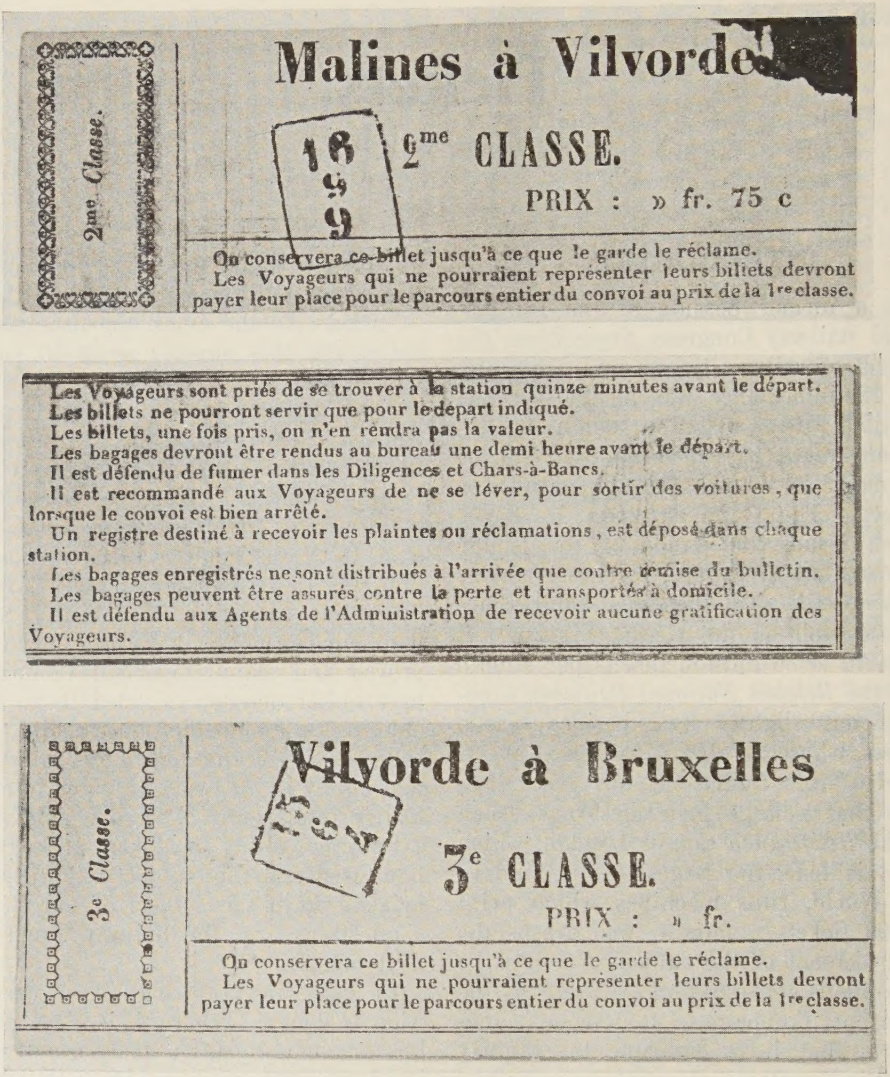
At a former Session of the International Railway Congress Association, the subject of railway tickets was gone into, and its importance was recognised. At the time (1910) a station such as Berlin-Anhalt might be called upon to deliver as many as 47 000 different kinds of tickets. The Gare de l'Est, in Paris, which issues 130 kinds of tickets for each station in France, reaches a higher number still. On the other hand, Companies such as the *Great Western* sell from 70 to 80 million tickets per annum and the *Belgian National Railways Company* but slightly less, besides season tickets, whose number is estimated at one third of this figure. If one also considers that a large printing Works such as the *Bell Punch Co.*, of London, which is, it is true, the largest of its kind in the World, runs machines which print 12 000 tickets a minute, one grasps the first element of the subject, to wit : the stupendous consumption of tickets by the Transport Companies. It is evident, therefore, that it is desirable to simplify ticketting systems as much as possible. Unluckily, other conditions intervene and somewhat hamper this. Owing to road and other competition, Railway Companies are constantly affording new facilities to the travelling public, each of which is embodied in new kinds of tickets.

Two contradictory conditions have, therefore, to be taken into consideration: on the one hand, the advisability of reducing the number of the different kinds of tickets, on the other, the necessity of increasing this number so as to satisfy new needs.

And further, a new element has materialised : this is the mechanisation of ticketting through self-printing and self-issuing machines. When the Berne Congress, where these problems were first gone into, was held in 1910, mechanisation was in its infancy and yet a resolution was passed in its favour. Since then, such machines have been much improved and many important Companies have either adopted or tried them, thus obliging the Companies, once again, to go into the ticket question. For all these reasons, it is necessary to enter into the matter in its entirety, commencing with a thorough study of tickets as they are now used and this subject might appropriately form the subject of one of the « questions » of the Railway Congress's next Session.

In gathering information concerning what is done elsewhere, it is often possible for one Company to make use of what has been successfully achieved elsewhere. As an instance of this, we quote two recent examples that have been brought to our notice within an interval of a few days :

When an important Railway Company owning a number of A.E.G. self-printing and issuing machines, recently raised its tariffs, it ordered a complete set of new


2me Classe.
Malines à Vilvorde
16 9 9
2me CLASSE.
PRIX : » fr. 75 c
On conservera ce billet jusqu'à ce que le garde le réclame.
Les Voyageurs qui ne pourraient représenter leurs billets devront payer leur place pour le parcours entier du convoi au prix de la 1re classe.
Les Voyageurs sont priés de se trouver à la station quinze minutes avant le départ.
Les billets ne pourront servir que pour le départ indiqué.
Les billets, une fois pris, on n'en rendra pas la valeur.
Les bagages devront être rendus au bureau une demi heure avant le départ.
Il est défendu de fumer dans les Diligences et Chars-à-Bancs.
Il est recommandé aux Voyageurs de ne se lever, pour sortir des voitures, que lorsque le convoi est bien arrêté.
Un registre destiné à recevoir les plaintes ou réclamations, est déposé dans chaque station.
Les bagages enregistrés ne sont distribués à l'arrivée que contre remise du bulletin.
Les bagages peuvent être assurés contre la perte et transportés à domicile.
Il est défendu aux Agents de l'Administration de recevoir aucune gratification des Voyageurs.
3e Classe.
Vilvorde à Bruxelles
3e CLASSE.
PRIX : » fr.
On conservera ce billet jusqu'à ce que le garde le réclame.
Les Voyageurs qui ne pourraient représenter leurs billets devront payer leur place pour le parcours entier du convoi au prix de la 1re classe.

Figs. 1 to 3. — Front and back of early paper tickets between fixed places. *Belgian State Railways* — 1838/1840. (Actual size).

plates. Had it known those then used by the *London and North Eastern Ry.* and others, which we describe hereafter, it need only have changed the movable parts of the plates and bought a few extra ones only. The cost, including la bour, would have been but a fraction o what was actually disbursed.

On another System, fraud on a larg scale was practised; an understandin

had been arrived at with the ticket collectors and the return portion of long-journey tickets was not collected. The date was easily altered and the tickets, returned to the places whence they were valid, then served a second time. This was only done to tickets of high denomination. After having studied many ways of preventing such misuse, the Traffic Department had special nippers made which dated the tickets in indelible ink (1). As these nippers were expensive, they were only served out to the staff of the more important stations.

The *Central Argentine Ry.* had previously had to deal with the same problem and had solved it differently. Instead of selling return tickets on the usual plan, long-distance return tickets comprised an ordinary going portion and, instead of a return one, a second portion which was really an exchange ticket with which the passenger paid, at reduced fare of course, and when about to start on his homeward journey, for a single (return portion) ticket. In practice, this system has proved entirely satisfactory.

It is unnecessary to quote further instances.

Light railways, tramways and bus lines. — Besides main and branch lines, many Companies maintain others which they work as light railways and instead of closing down unprofitable ones, there is a tendency to operate them in the same fashion. Some Companies, such as the *Belgian National Rys. Co.*, do so systematically. In these cases, the railway guard sells tickets as is done on any tramway line. As Railway Companies frequently work bus lines as well, it becomes ever more difficult to differentiate between the various classes of lines on each of which ticketting problems arise and must be dealt with. Experience gained on another class of line may be useful not only to similar ones but even, in many instances, to main-line railways as well and should therefore, not be neglected.

As an instance, the *Central Argentine Ry.*'s exchange return ticket is but the adaptation to a railway of a system which has long been in use on British tram and bus lines, so as to prevent the very fraud the railways we have quoted have had to fight against.

Definitions. — Apart from the standard railway tickets, a number of others are in daily use : booklets, paper tickets, etc. They all come under the generic heading of « tickets » (or « titres de transport », in French), but bear, as well, a number of other names.

It will make for lighter reading if we here state, once for all, how we shall designate the various kinds of tickets in future. It would have been preferable to restrict the name « ticket » to Edmondson's CARDBOARD TICKETS which are printed to standard dimensions 30.5 by 57 mm. (1 7/32" × 2 9/32").

A TICKET CARD is a cardboard ticket of larger size.

PAPER TICKETS explain themselves. Any detachable section of such a ticket is a COUPON and the portion that is kept for checking purposes is a STUB.

A number of such paper coupons, each available for a different section of a journey are bound together into BOOKS OF COUPONS; when all of them are identical, they form BLOCKS (or PADS in America).

In the following pages, when designating various entities, the term « Railway

(1) Similar nippers had already been used by the Company in 1901.

Company » is supposed to include not Companies only, but State Railway Administrations as well. Otherwise we would always have had to State « Railway Company » or « Administration », which would have been tedious.

* * *

Summary. — Railway tickets have several functions : they furnish a means of proving that there exists a contract between the carrier and the passenger; they are also a means of control and of statistics. Tariffs as such are outside the scope of this paper, but they enter into it when translated into tickets; therefore, the way card or paper tickets deal with the matter is important and besides the system of ticketting, each element of the ticket will have to be gone into, which comes to analysing its physiology. The pecuniary aspect of tickets will also be dealt with, as also issuing entities, And, last but not least, come the machines for printing or delivering tickets as they are needed and the special tickets required for the purpose. All these items naturally group themselves into ten parts, each of which is divided into chapters :

A — Status of railway tickets.
B — Physical aspect of tickets : substance and shape.
C — Systems of ticketting.
D — Pecuniary aspect. — Tickets and tariffs.
E — Special tickets.
F — Control and statistics.
G — Ticket-issuing entities.
H — The physiology of the ticket.
I — Self-printing and issuing machines.
J — Appendix.

References. — It is undoubtedly useful to quote one or two Companies where a ticket is or has been used, as this enables one, were further information needed, to secure it. But it would serve no useful purpose to give long lists of Companies using any ticket we may happen to quote.

Illustrations. — We have reproduced a considerable number of tickets as this does away with lengthy and inadequate descriptions. Besides this, it should be remembered that the ticket letterpress has to be squeezed into a cramped space and must yet remain clear and legible under conditions which are much more severe than those to which ordinary printed matter is subjected. It is, therefore, indispensable to reproduce it as it appears on the tickets and not as a fanciful typographical composition.

We have always stated what photographic reduction has been used. Save a very few exceptions when we have reproduced cardboard tickets in actual size we have reduced them to 4/5, which is practically two thirds of the available surface. The size of the paper ticket is so varied that it has not been possible to use so general a rule, but we have preferably, whenever possible, reduced such tickets to 3/4 of their actual size; exceptions mostly concern very large tickets (reduced to half size) and very small ones, reproduced full size.

Two ways of numbering the figures have occurred to us : either giving a number to each illustration and indices to each of the tickets of which it may be made up, or awarding a separate number to each of the latter whether grouped in a single illustration or not. This second system, which has been adopted, is far more convenient for reference purposes.

The legends state what the illustrations are supposed to show, but most tickets have special features, with which we deal in subsequent chapters. After the name of the issuing Company, we have therefore quoted such other items as may be

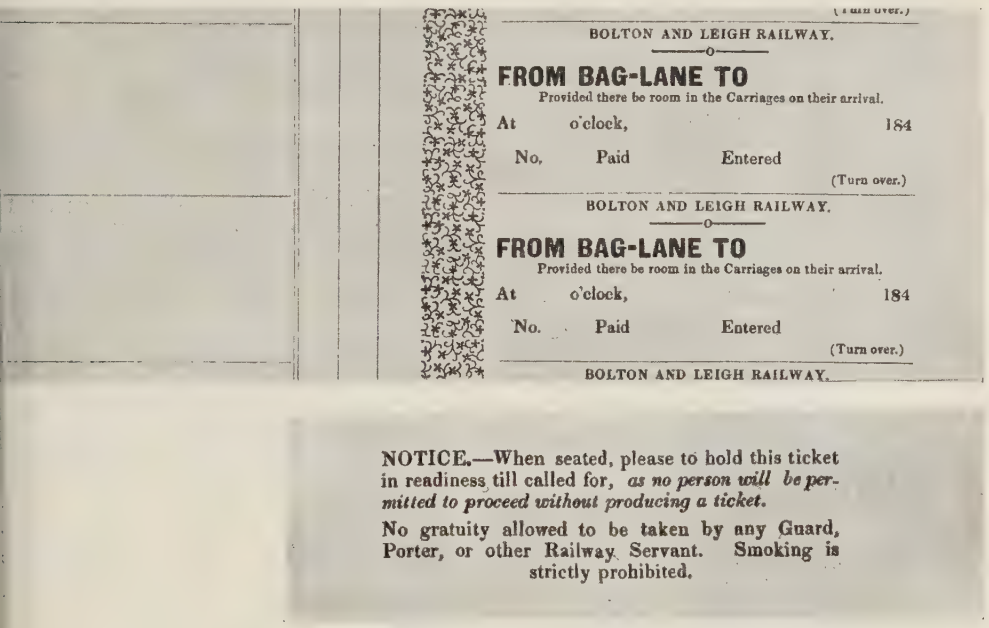
f interest, thus doing away with the ne-
essity of reproducing further tickets
or the purpose.

Note. — *Besides the illustrations in-
erted in the text, we shall often refer to
ther illustrations appearing in other
arts of this series of articles. These will
e shown in italics so as to distinguish
iem from the former.*

* * *

Ackowledgements. — We particularly
ish to express our thanks and indebt-
dness to the numerous Railway or Road
ransport Companies who have been
ood enough to reply to our queries or
ho have sent us samples of tickets, and
so to many ticket printing Firms who
ave helped us in various ways. We are particularly indebted to Messrs. *Guyot* of Brussels, *Roelants* of Rotterdam, the *Globe Ticket Co.* of New York, and *Fasbender* of Berlin, whose beautiful colour work we regret we are unable to reproduce. The London *Bell Punch Co.* has been particularly helpful not only in sending us numerous and varied specimens but also in supplying a number of papers on various ticketting subjects, all of which have been most useful.

Besides these, the manufacturers of all kinds of ticket machines have supplied a number of photos and descriptions of their appliances; we quote largely from them further on. We have also had interesting studies supplied by the French *Nord*, the *London Passenger Transport Board*, and many other Companies to all of whom we are grateful.


BOLTON AND LEIGH RAILWAY.
FROM BAG-LANE TO
Provided there be room in the Carriages on their arrival.
At o'clock, 184
No. Paid Entered
(Turn over.)
BOLTON AND LEIGH RAILWAY.
FROM BAG-LANE TO
Provided there be room in the Carriages on their arrival.
At o'clock, 184
No. Paid Entered
(Turn over.)
BOLTON AND LEIGH RAILWAY.
NOTICE.—When seated, please to hold this ticket in readiness till called for, as no person will be permitted to proceed without producing a ticket.
No gratuity allowed to be taken by any Guard, Porter, or other Railway Servant. Smoking is strictly prohibited.

Figs. 4 and 5. — Part of a sheet of early *Bolton and Leigh Ry.* tickets and back of one of them. (Red. 3/4).

PART A.

STATUS OF THE PASSENGER TICKET.

CHAPTER I.

The juridical aspect of passenger tickets should be considered from different angles. Such a ticket is not in itself a contract; it constitutes, as a matter of fact, a means of proving that such a contract between the carrier and the passenger does exist. But it is a very peculiar one and is not similar to any other save, perhaps, to a limited extent, to the contract between a theatrical producer and his patrons. It is often misstated that Carriers do not differ from other purveyors as they sell transport instead of other merchandise, but the cases are not comparable inasmuch as the journey takes place whatever the number of travellers, and even should there not be any at all. The contract simply allows them, under certain conditions, to participate in a given journey.

Payment usually takes place in advance, whereas when purchasing commodities, the opposite is the case, payment then taking place either upon delivery or later still. Tickets must be shown at any time, whenever the passenger is called upon to do so and may even be withdrawn on the way; the passenger must therefore always have them about him.

As the Company is not obliged to reimburse unused tickets, a ticket in other hands than the traveller's is valueless. On the other hand, a traveller without ticket is obliged to pay again, beside eventually, paying a fine (1). He may b allowed to prove that he had actuall bought a proper ticket, in which case n fine is levied.

The following Companies have bee good enough to send us studies concern ing the juridical aspect of Railwa Tickets, for which we are glad to than them :

The *French Main-Line Railways;*
The *London, Midland and Scottish Ry.* an the *London Passenger Transport Board;*
The *Great Southern Rys.* of Ireland;
The *Swiss Federal Rys.;*
The *Swedish State Rys.;*
The *Italian State Rys.;*
The *Belgian National Rys. Co.*

Transport contract. — A railway tick enables the passenger to prove that such contract exists, and is the means of h doing so (2). It is not in itself a contra which it simply represents. As will subsequently shown, it has other uses well.

Though a ticket proves the existen of a contract between the Company a the passenger, anybody travelling wit out a ticket and without fraudulent i tent is also a passenger and has equ rights with any other. Thus in Be gium, and also in France, anyone m board a train at certain staffless ha

(1) The first Belgian tickets stated that passengers without tickets always had to pa a first-class fare (fig. 1).

(2) Belgian Law of 25 August 1891, art. 1*a*.

and subsequently pay for his passage when in the train, whereas the actual contract has begun previously : in Belgium, the moment the passenger entered the railway carriage.

(fig. 10), and certain Brazilian ones bore no other wording whatever (fig. 9) (1). The same idea is to be found in the wording of certain Swiss tickets which were entitled « Récépissé de perception »

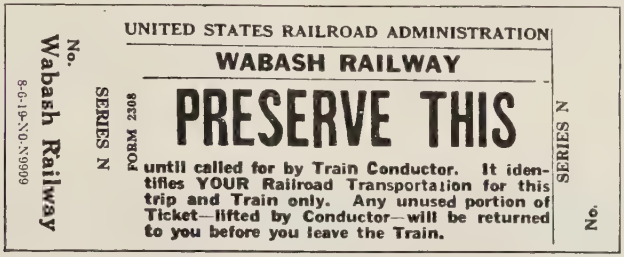

UNITED STATES RAILROAD ADMINISTRATION
WABASH RAILWAY
PRESERVE THIS
until called for by Train Conductor. It identifies YOUR Railroad Transportation for this trip and Train only. Any unused portion of Ticket—lifted by Conductor—will be returned to you before you leave the Train.
No. Wabash Railway
8-0-19-NO-N9999
SERIES N
FORM 2308
SERIES N
No.

Fig. 6. — Identification ticket — *Wabash Ry.* (Red. 3/4).

British jurisprudence takes a slightly different view. According to the *L.M.S.*, the ticket handed to the passenger (and this is where the main difference lies) is in itself a contract which obliges the Company, in consideration of the price paid by the passenger, to carry him within a reasonable time and with all due care and diligence to the destination specified on it.

This is also the case in Ireland *(Gt. Southern Rys.)* where

« The sale of a railway ticket by a Railway Company to a passenger constitutes an express contract whereby the Company undertakes the responsibility of conveying the passenger... »

Fares. — The ticket is also the means of proving that the correct fare has been paid (fig. 7). In the States, certain of the *Pullman Co.*'s tickets even bear the words :

« To identify accommodation purchased » (fig. 8).

Several very old tickets even went as far as to state that they were « receipts »

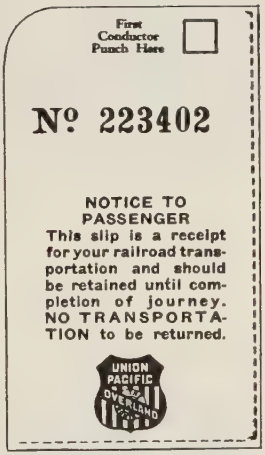

First Conductor Punch Here
No 223402
NOTICE TO PASSENGER
This slip is a receipt for your railroad transportation and should be retained until completion of journey. NO TRANSPORTATION to be returned.
UNION PACIFIC
OVERLAND

Fig. 7. — Receipt-ticket of the *Union Pacific R.R.* (Red. 3/4) — With space for punching, and Company's crest).

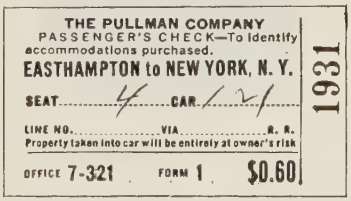

THE PULLMAN COMPANY
PASSENGER'S CHECK—To identify accommodations purchased.
EASTHAMPTON to NEW YORK, N. Y.
SEAT 4 CAR 1 1 1
LINE NO. VIA R. R.
Property taken into car will be entirely at owner's risk
OFFICE 7-321 FORM 1 $0.60
1931

Fig. 8. — Proof of contract — *The Pullman Co.* (Red. 3/4).

(1) In Pelotas, Bello Horizonte and elsewhere (Brazil).

Fig. 9. — Receipt-ticket without name of Company or of station — *Pelotas*, Brazil (Red. 3/4).

other considerations (fig. 11) (2). Of course, a ticket being a receipt is subject, in France for instance and with certain exceptions, to the usual fiscal duty. These exceptions comprise :

Personal tickets (ordinary or workman's season tickets) and tickets delivered on presentation of a personal identity card (such as large-family tickets, war pensioners, discharged soldiers, special half-price tickets, etc.).

Tickets are issued to bearer or his de-

MALINES A BRUXELLES.
Départ du 1835,
WAGGON N°
PLACE N° 19.
à 3
heures du
Reçu 50 centimes.
Le Receveur,
26
Les voyageurs sont priés de se trouver à la station quinze minutes avant l'heure du départ.
N. B. On conservera ce billet jusqu'à ce que le Garde le réclame.

Fig. 10. — Reproduction, in actual size, of first Continental steam railway ticket — *Belgian State Railways*. — This ticket is a receipt — Seats are numbered.

(receipt for perception) (1). In Germany, whereas this idea was sometimes resorted to, it was usually bound up with

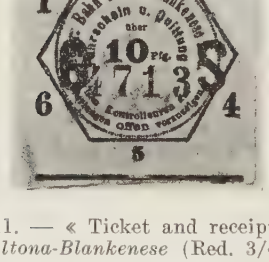


Fig. 11. — « Ticket and receipt » — *Altona-Blankenese* (Red. 3/4).

legate, but may not be transferred to a third party. The French bye-laws state (3) that :

« the carriage of passengers takes place after previous payment of fares ».

It is thus only with intending travellers that the Company intends to deal.

Curiously enough, **the ownership of railway tickets** — whether they belong to the Company or to the passenger — is an open question in most countries. At first sight, it would seem that save when otherwise stated by law, they belong to the Company, and the fact that

(1) *Geneva Steam Navigation Co.*

(2) Altona-Blankenese : « Fahrschein und Quittung » (Ticket and receipt).

(3) Art. 4, General Tariffs applicable to passengers, passengers' luggage and dogs.

hey are usually collected at the end of he journey would seem to prove it. But here are objections to this opinion.

The first of them arises when one con-iders that in many (if not most) sta-ions, access to the trains is only possi-le : *(a)* upon purchase of a ticket, and *b)* after the barriers have been passed. The booking offices being outside these arriers actually sell tickets when the ompanies' transport services have not et been made use of; besides this, it is owhere stated that after buying a ticket, he purchaser is obliged to travel. Were e forced to do so, it would seem that ooking offices would be placed inside nstead of outside the station barriers. nd this point of view is strengthened hen one considers that other booking ffices which exist elsewhere, outside the ompany's premises, whether belonging it or to private Agencies, also sell ckets without stating whether or not ey have to be used for travelling. Add this that on most light railways and ad transport lines, passengers retain eir tickets after alighting from the rs.

All this may be but toleration but it ems advisable to elucidate the point as e status of the ticket is thereby affect-. Suppose, for instance, a ticket is sto-n from a passenger who has not yet be-n his journey and that the thief be ught. The passenger alone will be the intiff, the Company never appearing the matter. Of course, this is not act-ual proof of non-ownership but it is worth thinking over.

Lastly, when a Company issues a through ticket over lines belonging to several other Companies, does the ticket or do portions of the ticket belong to each of them in succession?

Another way of looking at things has been suggested by Mr. Renieu who considers that the ticket which is (or proves the existence of) the contract is the joint property of both parties and that it is simply retained in trust by one or other of them according to mutual convenience. The purchaser is then supposed, by the simple fact of having accepted the ticket at the booking office, to have approved of the conditions under which the ticket is issued. This appears to take into account, in countries where the status is not legally fixed, both the legal point of view and any existing bye-laws. Elsewhere, the status varies.

In France, which is an exception, the ticket belongs to the passenger, who is allowed to sell it before commencing his journey.

« Save exceptions stated in the bye-laws, tickets may only be sold if they are not personal and if the journey has not begun (1) ».

But though the passenger is the actual owner of the ticket, he may not deal with it as he thinks fit (2), a limited property only being vested in him.

Should any of the Company's officers collect the ticket in the course of the

(1) *C.I.V.*, art. 6, par. 5, dealing with international transportation.

(2) He may not cede the return portion of a return ticket (art. 21, law of 21 July 1845, laborated by Ordinance of 15 Nov. 1846, art. 76, modified by Decree of 11 Nov. 1917, rt. 97).

Tickets belonging to other passengers may not be borrowed for registering passenger's ggage, the free luggage carriage (30 kgr. = 66 lb.) being an accessory of the ticket.

Sarret writes that the right to such freedom is vested in the passenger and is therefore ntransferable.

journey, he must give a receipt for it. When the journey is ended and the ticket about to be withdrawn, any passenger having a grievance against the Company should ask for a receipt in exchange for it. And still a further proof of the passenger's ownership is that, should he claim reimbursement of an unused ticket whose period of validity has run out, such reimbursement is refused but the ticket is returned to him.

In BELGIUM, the bye-laws used not to be sufficiently clear and only stated that:

« the ticket also enables the passenger to prove that the price of the journey has been paid ».

This has been completed by law (1) as follows :

« Passengers must show and even hand over their tickets to the Company's staff whenever required to do so and must give them up for collection, according to the Company's bye-laws, either in the trains or at the station's exit. »

In SWITZERLAND, the law is not as explicit but the ticket's status is easy to deduce as the *Federal Rys.* are but a section of the Federal Administration and the Swiss State is sole proprietor of all these railways.

According to the Federal Tribunal's jurisprudence (2), tickets issued by the *Federal Rys.* are considered to be federal documents (3), the conditions required, to wit, concerning their origin and the status of the issuer (4), being fulfilled. There is therefore no need to discriminate whether the contents are of a public or a private character. So whether it belongs to public law or not is immaterial.

Another conclusion that should be drawn is that the status of tickets issued by private Swiss Companies is different these being ruled by the several Swiss cantonal jurisdictions (5).

In ENGLAND, the problem does not arise at all, the first article of the Companies bye-laws stating that « the tickets are the property of the Company ». There is a slight difference concerning tickets issued by Colonial Government Railways; in Ceylon, for instance (fig. 12), before the

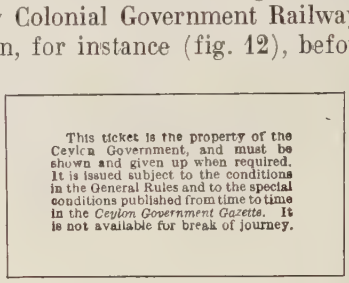

This ticket is the property of the Ceylon Government, and must be shown and given up when required. It is issued subject to the conditions in the General Rules and to the special conditions published from time to time in the *Ceylon Government Gazette*. It is not available for break of journey.

Fig. 12. — Property of a ticket — *Ceylon Government Rys.* (Red. 4/5).

usual recommendations concerning conditions of issue, etc., they bear the words:

« This ticket is the property of the Ceylon Government. »

It is therefore on the same footing as other Government property.

(1) « Arrêté Royal » (Royal Order) of 4 April 1895, art 7 (*Moniteur* of 19 and 21 April, 1895) which altered that of 3 August, 1887, 1st Part, pp. 558 and following.

(2) Official book of laws (arrêtés).

(3) Falsification falls under penalties stated in art. 61 of Federal penal Code.

(4) According to the Federal Tribunal.

(5) See Par. 9, 10, 11, 15 and 16 of the Regulations for Swiss Railway and Steamboat Transport Companies, 1st Jan. 1894.
See also HANS SCHWEINDENER : Das Personentransportrecht mit besonderer Berücksichtigung des schweizerischen Post-, Eisenbahn-, und Dampfschiffverkehrs, Berne 1911.

Conditions of issue. — Tickets are issued subject to the Companies' bye-laws, and passengers must obey them. Formerly, a number of these conditions used to be printed on the ticket itself and when space was insufficient on the back of it, but so as to be binding, the passenger should have had the possibility of reading it. This was seldom the case as he would obstruct all other passengers were he to start reading these conditions at the booking office window. Several findings of Continental Law Courts have upheld this contention.

For this reason, only a few of the most important clauses are now printed on the tickets; these include mainly the fact of their being untransferable, the obligation to show them when required and when opportune, and others concerning the Company's responsibility or conversely. Other steps have been taken concerning the other conditions.

In England, before Edmondson's tickets had been invented, the paper tickets bore a few of these conditions on both sides, such as :

« No person will be allowed to proceed without producing a ticket (1) »

or else:

« This ticket must be shown at the Station but must be kept to present it to the Guard of the coaches at... Station (2). »

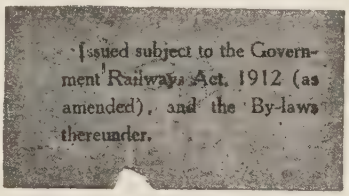
Other conditions concerning the journey, but not the ticket itself, followed.

When Edmondson produced his cardboard tickets, space for such conditions was lacking so they were barred for quite a time, but as they were really necessary, they reappeared about 1862 (3) timidly at first, later more imperatively (figs. 13 and 14), as hereunder :

« Issued subject to the Regulations in the Company's timetables »

or, more generally :

« Issued according to the Company's bye-laws. »



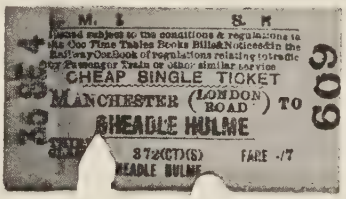


Fig. 13. — Notice on back of ticket — *New South Wales Govt. Rys.*

Fig. 14. — Notice on front of ticket — *L. M. and S. Ry.* (Red. 4/5). — Category : cheap fare ticket.

This formula was clearly shown and, so as to draw the passenger's attention, was sometimes printed in negative type (4) or even in red (5).

As special clauses relating to certain tickets were to be added, the entire back of the ticket was devoted to them, in England since 1875, in Belgium, earlier.

(1) *Bolton and Leigh Ry.*, 1840 odd.
(2) *London and Warrington Ry.*, 1832.
(3) *Midland Ry.*
(4) *Southern Ry.*
(5) *Great Western Ry., Metropolitan Ry.*

As a corollary, words advising the passenger to read what was on the other side were added on the front, such as « See back » (1) or « Turn over », or more often, « See conditions back » (2). The object was of course to bring to the passenger's notice the fact that special clauses existed so that he might not argue that he had no knowledge of them. Such conditions are also reproduced in the Companies' timetables, besides being printed in handbills and posters.

It has been decided in British Courts (in 1930) (3) and in 1931 (4) that provided the ticket itself is printed sufficiently clearly to draw the passenger's attention to the existence of special conditions, the fact that those conditions have to be found in another document, even if not easily obtainable, does not prevent the conditions from being effective to bind the passenger. The necessity for a judicial decision on the point does not appear to have arisen in the High Courts of the Irish Free State but it is assumed their views would coincide with those of the English Courts.

The contractual nature of tickets is emphasized by certain Companies in the very wording they use. Thus the *L.M.S.* states that « The acceptance of it (the ticket) is to be taken as evidence that the Rules, Regulations and Public Notices relating to the tickets, in connection with which this ticket is issued, are understood by the holder ».

This seems at first sight to be somewhat drastic as it is somewhat difficult, is it not, for the holder to judge himself whether or not he has properly understood these rules and regulations?

Continental booklets of coupons and American interline paper tickets, are issued nominatively, and by signing their name to these paper tickets, the holders bind themselves to respect all the clauses and regulations to which they are subject.

Such acceptance is particularly important in the U.S.A. where tickets are more frequently issued for very long journeys than is the case with us and therefore cost larger amounts. For this reason, the principal clauses are reproduced on the upper portion of the long band-tickets which become valid only when stamped and dated on the back. Not only does the intending passenger sign for acceptance of the conditions, but the issuing agent signs as witness as well. Furthermore, so as to show the contract has been accepted by the Company, the facsimile of the chief passenger agent (or a Vice-President) is also reproduced on the ticket. Many of these tickets even bear the slogan

« Read your contract. »

or others to this effect.

Transferability of railway tickets. — Generally speaking, from the moment the journey has begun, tickets are non-transferable, but in some countries they may be ceded up to this time, in others, not.

In FRANCE, tickets are transferable when they are not nominative and when the actual journey has not begun. It is

(1) *South Eastern Ry., District Ry.*

(2) *Lancashire and Yorkshire Ry.*

(3) Thompson *v. L.M.S.*

(4) Penton *v. Southern Ry.*

therefore, allowed to have a ticket bought by a third party or to sell a single ticket before using it, whereas the return half of a return ticket may never be sold or transferred, as the commencement of the journey took place when starting on the outward trip.

In Belgium, even when the ticket is to bearer and not nominative, it is personal and untransferable (1). This condition, which in practice is almost impossible to enforce, has been maintained in the bye-laws with the sole purpose of legally prohibiting the systematic sale and purchase of tickets by others than the proper issuing entities.

In Ireland *(Great Southern Rys.)* as in England (2), the bye-laws prohibit the sale, transfer or receipt of non-transferable tickets and both sellers and purchasers, transferrors and transferrees, are subject to a legal penalty. The performance of the contract is thus restricted to the person with whom it is made and prevents the acquisition of tickets by persons who, by obtaining them free or cheaply, would travel under conditions financially disadvantageous to the Company.

In the *U.S.A.*, owing to the large amounts involved, cession of return portions is particularly objectionable. When a settler uses a « home seeker's ticket » available nine months, he is naturally tempted to sell the unused portion that may remain after he has fixed his choice. To prevent this, besides his signature as accepting the conditions of issue (which include non-transference), the Companies added in 1890, as a further means of protecting their rights, a succinct description of the holder, the guard perforating such indications as apply to the bearer's sex, girth, height, age, colour of eyes and hair, etc. (fig. 15). And besides all this, the return portion is only available after the holder has proved that he (or she) is the original purchaser and after the clerk has also signed it for validation.

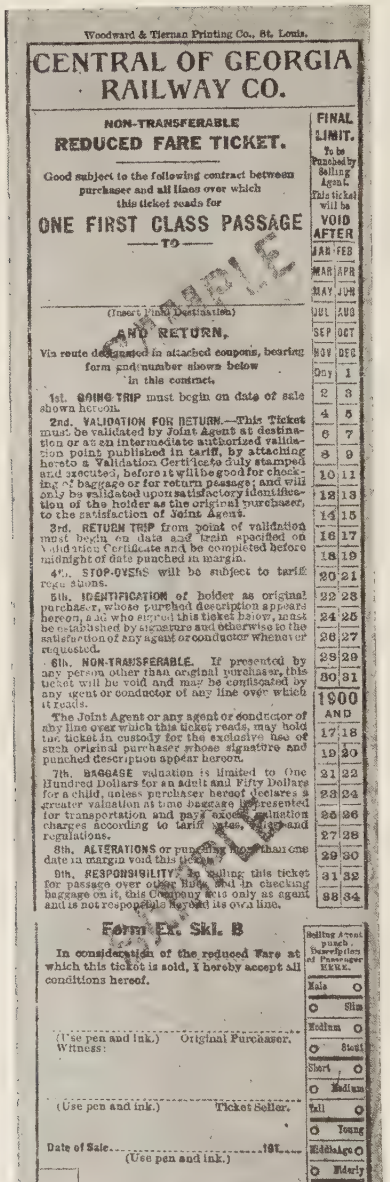
Company's obligations. — The acceptance of a contract between two parties entails mutual obligations which come into being as soon as the Company has received the passenger's payment of his fare. The Company must carry him with all due diligence to his destination in the class for which he has paid.

Classes. — In Belgium, the Company must place at the traveller's disposal a seat or standing room in a carriage or compartment of the class in which he has the right to travel (save in the case of limited trains) or in a higher class than he has paid for. But the Company may not, even when reimbursing the difference in price, oblige him to travel in a lower class, without his agreement. In the same way, a passenger may protest if a passenger of a lower class is allowed to enter his compartment without paying in consequence.

Timetables. — The punctuality of trains must, save cases of unavoidable circumstances, be maintained. But it would seem that in England, the times given in the timetables are those before

(1) Art. 2, Par. 3 of the bye-laws. Those concerning full-price or reduced-price fares are included in Portions I and II (pages 5 to 16) of the regulations and bye-laws issued by Ministerial Decree of 18 March 1932 (*Moniteur*, 20 March 1932), amplifying the text of the law of 25 August 1891, Art 13.

(2) *Furness Ry.* : « Its transfer is an indictable fraud ».



Woodward & Tiernan Printing Co., St. Louis.

CENTRAL OF GEORGIA RAILWAY CO.

NON-TRANSFERABLE

REDUCED FARE TICKET.

Good subject to the following contract between purchaser and all lines over which this ticket reads for

ONE FIRST CLASS PASSAGE

—TO—

(Insert Final Destination)

AND RETURN,

Via route designated in attached coupons, bearing form and number shown below in this contract.

1st. GOING TRIP must begin on date of sale shown hereon.

2nd. VALIDATION FOR RETURN.—This Ticket must be validated by Joint Agent at destination or at an intermediate authorized validation point published in tariff, by attaching hereto a Validation Certificate duly stamped and executed, before it will be good for checking of baggage or for return passage; and will only be validated upon satisfactory identification of the holder as the original purchaser, to the satisfaction of Joint Agent.

3rd. RETURN TRIP from point of validation must begin on date and train specified on Validation Certificate and be completed before midnight of date punched in margin.

4th. STOP-OVERS will be subject to tariff regulations.

5th. IDENTIFICATION of holder as original purchaser, whose purchase description appears hereon, and who signed this ticket below, must be established by signature and otherwise to the satisfaction of any agent or conductor when so requested.

6th. NON-TRANSFERABLE. If presented by any person other than original purchaser, this ticket will be void and may be confiscated by any agent or conductor of any line over which it reads.

The Joint Agent or any agent or conductor of any line over which this ticket reads, may hold the ticket in custody for the exclusive use of such original purchaser whose signature and punched description appear hereon.

7th. BAGGAGE valuation is limited to One Hundred Dollars for an adult and Fifty Dollars for a child, unless purchaser hereof declares a greater valuation at time baggage is presented for transportation and pays excess valuation charges according to tariff rates, rules and regulations.

8th. ALTERATIONS or punching more than one date in margin void this ticket.

9th. RESPONSIBILITY. In selling this ticket for passage over other lines and in checking baggage on it, this Company acts only as agent and is not responsible beyond its own line.

Form Ex. Skl. B

In consideration of the reduced Fare at which this ticket is sold, I hereby accept all conditions hereof.

(Use pen and ink.) Original Purchaser.

Witness:

(Use pen and ink.) Ticket Seller.

Date of Sale.....191....

(Use pen and ink.)

F. J. Robinson
Gen'l Passenger Agent,
Savannah, Ga.

FINAL LIMIT.

To be Punched by Selling Agent. This ticket will be VOID AFTER

JAN	FEB
MAR	APR
MAY	JUN
JUL	AUG
SEP	OCT
NOV	DEC

Day	1
2	3
4	5
6	7
8	9
10	11
12	13
14	15
16	17
18	19
20	21
22	23
24	25
26	27
28	29
30	31
1900 AND	
17	18
19	20
21	22
23	24
25	26
27	28
29	30
31	32
33	34

Selling Agent punch Description of Passenger HERE.

Male	O
O	Slim
Medium	O
O	Stout
Short	O
O	Medium
Tall	O
O	Young
Middle-age	O
O	Elderly
Light Hair	O
O	Dark Hair
Gray Hair	O
O	Female

Fig. 15. — Portion of American ticket-band setting out conditions of issue — *Central of Georgia Ry. Co.* (Red. 3/4) — Contains notices to passengers, identification and summary description of original purchaser — Date of utilisation to be punched in lists of items.

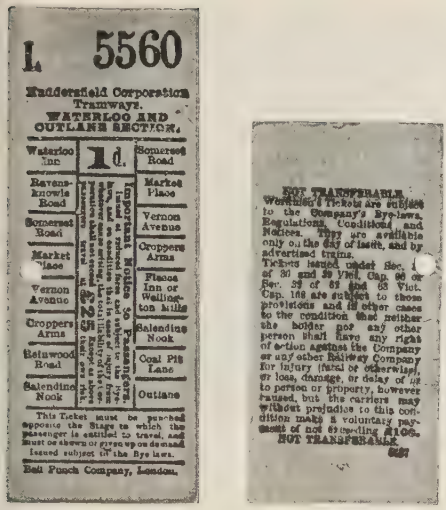
which the Company undertakes that its trains shall not leave but they are not tied down to arrive punctually if the Company has previously taken all reasonable steps for them to do so.

The Companies' liability. — **Damages** — While the Company is not an insurer of the safety of the passenger or his luggage, it is liable to him for damages in the event of the Company or its servants failing to exercise the reasonable care and diligence which the existence of the contract requires. The word « reasonable » qualifies such conditions in a curious way. If, for example, a passenger is injured in the course of his journey as a result of the development of a latent defect in a coach « reasonable expenditure of skill or foresight » could have detected or prevented, the Company is not legally liable for any resultant injury to the passenger.

But when the Railway Company is liable, such liability is not confined to the passenger. In the event of a fatal accident to him, his legal personal representatives may sustain a claim against the Company.

These considerations enter into our subject because they have to be taken into account when issuing tickets. Certain tickets practically insure passengers against all or limited risks (fig. 16), others have no insurance value. This even applies to unjustifiable unpunctuality, to loss or damage to luggage and in some cases, causes the Companies to issue special reimbursement tickets which are in daily use in the United States.

Luggage liability is frequently limited in the U.S.A., to $ 100 (fig. 18), and to $ 50 for full-price and half-price (children's) tickets respectively, unless a higher rate of carriage be applied.



NOT TRANSFERABLE
Workmen's Tickets are subject to the Company's By-laws, Regulations, Conditions and Notices. They are available only on the day of issue, and by advertised trains.
Tickets issued under Sec. 1 of 30 and 31 Vict. Cap. 96 or Sec. 37 of 57 and 58 Vict. Cap. 148 are subject to those provisions and in other cases to the condition that neither the holder nor any other person shall have any right of action against the Company or any other Railway Company for injury (fatal or otherwise), or loss, damage, or delay of or to person or property, however caused, but the carriers may without prejudice to this condition make a voluntary payment of not exceeding £100.
NOT TRANSFERABLE

ig. 16. — Company's responsibility — *Huddersfield Corporation Tramways* — List of sections (Red. 4/5).

ig. 17. — Non-responsibility of the Company — Back of workman's ticket.

It should be noted that in Belgium, for istance, the fact of being in possession a ticket does not necessarily involve e carrier's responsibility; the journey ust have « effectively commenced » (1). he execution of the contract only starts hen the passenger begins getting into e carriage (2). This alters previous ru- igs whereby the Company became li- le from the moment a seat was bought d its price paid (3).

In any case, the Company always as- mes considerable responsibility even

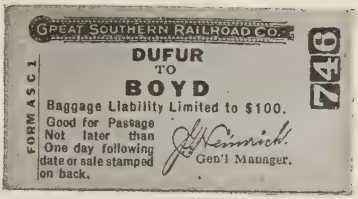


Fig. 18. — Limited baggage liability — *Great Southern R. R. Co., U.S.A.* (Red. 4/5) — Availability — Officer's signature.

should it be difficult to prove it in the wrong. It has therefore striven to shed such responsibility by making special contracts with its passengers. This is effected by the issue of special tickets of longer duration or of lower fares than those it is obliged to issue, in exchange of which passengers agree to wave their right to partial or total compensation in case of mishap (fig. 17). It is essential, for such special contracts to be legal, that intending passengers should have knowledge of these clauses or at least, of their existence. We have seen previously how this is accomplished.

But besides this, the Companies must respect their own legal obligations. It is therefore indispensable that the passenger should have the option of making the same journey on an ordinary ticket at a higher fare, the Company then incurring full responsibility.

When issuing cheap excursion tickets, the Company completely sheds this responsibility, whatever the cause of the casualty be (4). This not only applies to

(1) Tribunal Civil de Charleroi, 15 Jan. 1912 (*Journal des Tribunaux*, page 217).

(2) Art. 1382 and 1384 of the *Code Civil* (Brussels, 25 July 1912, *Pandectes périodiques*, 913, No. 347) rule all questions of responsibility in the case of accidents to passengers olding tickets, whilst in stations, both when awaiting trains they are to take or whilst roceeding to them.

(3) Tribunal de Commerce, Antwerp, 30 March 1874 (*Belgique judiciaire*, 1874, page 462).

(4) *London and North Eastern Ry.* platform tickets bear the following : « This ticket issued on the condition that the Co. will not be liable to the holder for any injury r loss personal or otherwise, however caused. »
London Passenger Transport Board : « ... and to the special conditions relating to cheap ckets ».

railways, but also to tramways (1) and light railways, and similar restrictions apply to workmen's tickets as well (2).

Interline responsibiliy. — With regard to through tickets, available for a journey extending partly on the issuing Company's own line and partly on the line of another Company, the legal position in England is that in the absence of a contract to the contrary, the issuing Company is legally liable for the safe conveyance of the passenger through to his destination, and for any injury that may befall him owing to lack of reasonable care and diligence irrespective of the line on which such injury may occur. As the passenger has always a legal redress against the Company actually guilty of negligence, it is, therefore, open to him in the case of such through tickets, to choose which Company he will sue, or to sue both.

This serious burden on the issuing Company can be avoided by special contract with the passenger and it is invariably a condition of the issue of through tickets that the issuing Company shall not incur any responsibility for loss, injury, etc., occurring off the issuing Company's lines. When this condition is brought to the passenger's notice (by pu blication in the Company's timetable bills and notices), it forms part of th contract and legally binds the passenge

Similar clauses are printed in all book lets of coupons and on practically a tickets sold by ticket issuing Agencie

Passenger's obligations. — The tick which proves the existence of a contra between the holder and the Company, the token of their reciprocal obligation

So as to justify that he is proper using the Company's services (clas train, seat, etc.), the passenger mu show his ticket whenever requested to d so. He must also show it if required c entering or leaving the train. Fraud punished and penalties are frequent printed on the tickets themselves (3).

A ticket may be used only between th places stated thereon (4) and sometime only by the first train available for th purpose (5).

When a ticket is not properly use not only is it confiscated and full fa demanded but the holder is mulcted wi a fine as well. Thus if the holder of platform ticket entered a train in Sal burg, he was fined 3 gulden. Simil penalties are frequently enforced

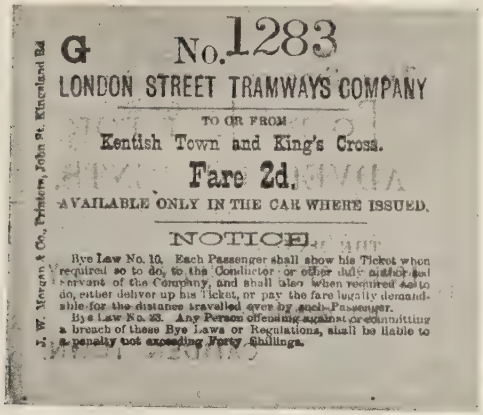
(1) At Huddersfield : « Issued at reduced fares; the total liability of the Corporatio shall not exceed £ 25. Except as above, passenger travels at his own risk. »

(2) *Southern Ry.* tickets bear : « no redress ».

(3) It was stated on certain old *Belgian State Rys.* tickets, that passengers travellin without proper tickets were « liable to prosecution ».
And on *Great Western Ry.* tickets : « The fare paid will be forfeited and the ticke rendered void should the holder use it by any other train or for any other station and h will in addition be required to pay the full ordinary fare for the journey travelled. »
On *London County Council Tramways* tickets : « Avoiding payment of fares, Section 5 of the Tramways Act of 1870, which provides for the infliction of a penalty on a passenge who avoids or attempts to avoid payment of the fare or who, having paid the fare, travel beyond the stage for which the ticket has been issued, without payment of the addition fare. »

(4) On the *Furness Ry.* : « Available only to and from stations named thereon ».
South Eastern and Chatham Ry. tickets bore : « If used for any other station, th ticket will be cancelled and the full fare charged ».

(5) This is the case on the *F. C. Nordeste Argentino.*


G No. 1283
LONDON STREET TRAMWAYS COMPANY
TO OR FROM
Kentish Town and King's Cross.
Fare 2d.
AVAILABLE ONLY IN THE CAR WHERE ISSUED.
NOTICE.
Bye Law No. 10. Each Passenger shall show his Ticket when required so to do, to the Conductor or other duly authorised servant of the Company, and shall also when required so to do, either deliver up his Ticket, or pay the fare legally demandable for the distance travelled over by such Passenger.
Bye Law No. 23. Any Person offending against or committing a breach of these Bye Laws or Regulations, shall be liable to a penalty not exceeding Forty Shillings.
J. W. Morgan & Co., Printers, John St. Kingsland Rd.

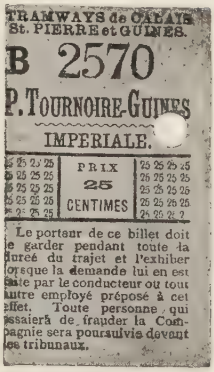

TRAMWAYS de CALAIS, St. PIERRE et GUINES.
B 2570
P. TOURNOIRE-GUINES
IMPERIALE.
PRIX 25 CENTIMES
Le porteur de ce billet doit le garder pendant toute la durée du trajet et l'exhiber lorsque la demande lui en est faite par le conducteur ou tout autre employé préposé à cet effet. Toute personne qui essaiera de frauder la Compagnie sera poursuivie devant les tribunaux.

Fig. 19. — Penalties for fraud — *London Street Tramways Co.* (Red 3/4) — Old paper ticket — Available for one section.

Fig. 20. — Warning and eventual prosecution — *Calais St. Pierre and Guines Tramway* (Red. 4/5) — Category : upper deck ticket — Safety background (numerals).

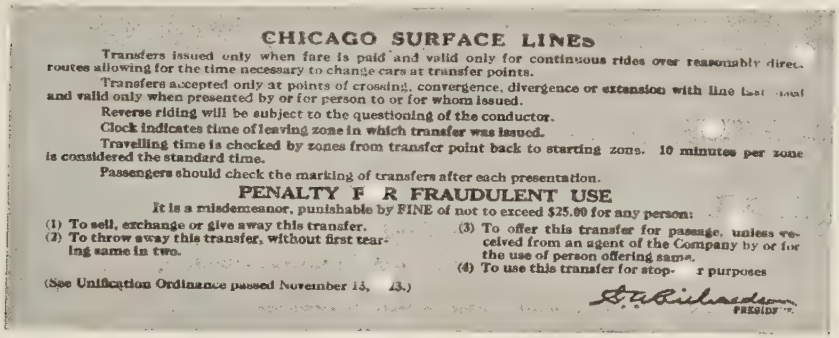

CHICAGO SURFACE LINES
Transfers issued only when fare is paid and valid only for continuous rides over reasonably direct routes allowing for the time necessary to change cars at transfer points.
Transfers accepted only at points of crossing, convergence, divergence or extension with line last used and valid only when presented by or for person to or for whom issued.
Reverse riding will be subject to the questioning of the conductor.
Clock indicates time of leaving zone in which transfer was issued.
Travelling time is checked by zones from transfer point back to starting zone. 10 minutes per zone is considered the standard time.
Passengers should check the marking of transfers after each presentation.
PENALTY FOR FRAUDULENT USE
It is a misdemeanor, punishable by FINE of not to exceed $25.00 for any person:
(1) To sell, exchange or give away this transfer.
(2) To throw away this transfer, without first tearing same in two.
(3) To offer this transfer for passage, unless received from an agent of the Company by or for the use of person offering same.
(4) To use this transfer for stop-over purposes
(See Unification Ordinance passed November 13, 23.)
PRESIDENT

Fig. 21. — Conditions ruling issue of transfers and penalities for fraudulent use — *Chicago Surface Lines* (Red. 3/4).

Tramway Companies : in Milan, a passenger holding no ticket was made to pay, not only his fare but a 2-lire fine (1); in London, this fine reached 10 shillings (fig. 19) (2), whereas in Calais, passengers were warned they would be brought before the Courts (fig. 20).

In the U.S.A., the large use of transfers between railways or road transportation is ruled by clauses drafted so as to prevent their misuse. They always carry a notice to passengers stating the penalties for fraudulent use as, for instance, on obsolete New York tickets :

« A person unlawfully using this transfer is guilty of a misdemeanor under section 1566 of the Penal Code, which is punishable by emprisonment for not more than one year and a fine of not more than Five Hundred Dollars or both. »

(1) R/D No. 1127 of the 17 July, 1921.
(2) The *London Street Tramways*.

Elsewhere, the cases of misuse are listed and the penalty, usually a smaller one, seldom exceeds $ 25 per person (1).

In all cases, a passenger must behave decently; if he is rude or the worse for drink, he may be debarred from pursuing his journey. He must also occupy the seat that is awarded him.

Tickets often carry (and more often still in former times) warnings concerning smoking. The early English paper tickets were often as under :

« Smoking in first-class carriages strictly prohibited. »

The old *Great Western* tickets were more drastic and entirely forbade smoking at all. Towards 1885, *Belgian State Ry.* tickets took up the (Continental) much discussed open window question forbidding :

« to open the windows on the side from which the wind came, unless all the passengers agreed to so doing ».

The carriage of dogs was forbidden

« in all passenger-carrying coaches ».

Passengers were advised that they might

« send their luggage to any *State Ry.* station other than the one they were proceeding to ».

And reverting to notices that were so general at the outset of any railways at all, they strictly forbade tipping the guards.

Dissimilarity of passenger and luggage or merchandise contracts. — As we only deal with the former, there is no need to go deeply into this aspect of the subject, it being sufficient to state that passengers, animals (per passenger trains) and luggage are solely dealt with.

It is not without interest to draw attention to the fact that in opposition to what has frequently been stated, a railway ticket is, from a legal point of view, in no way comparable with a postage stamp. There is, it is true, a certain similarity in service rendered : prepayment of both of them; accomplishment of a great part of the carrier's side of the contract whether the second party (the public) takes part in its accomplishment or not; deliverance of the contract (ticket or postage stamp) which accompanies the carryee (passenger or letter). But there remains the fundamental difference embodied in all countries' legislation that exists between the carriage of persons and the carriage of things.

We might add that whereas it would seem that it is generally considered that railway tickets are the property of the seller, postage stamps seem always to be the property of the buyer. Post Offices even sell collections of postage stamps that they know will never be used to frank letters. And whereas it is nowhere stated that the purchaser of a railway ticket is obliged to use it for travelling, there is a tacit convention to this effect which is not the case with postage stamps. Lewis Carroll might have added « contrariwise ».

(1) On the *Chicago Surface lines* (fig. 21) :

« 1. To sell, exchange or give away this transfer;

« 2. To throw away this transfer, without first tearing same in two;

« 3. To offer this transfer for passage, unless received from an agent of the Company or for the use of person offering same;

« 4. To use this transfer for stop-over purposes (See « Unification Ordinance », November 13, 1913). »

PART B.

PHYSICAL ASPECT OF RAILWAY TICKETS.

CHAPTER II.

SUBSTANCES USED.

With the exception of leather, metal and a few other substances, cardboard and paper are exclusively used for printing tickets upon. The latter must have certain essential qualities without which poor tickets would be produced. The card or paper must be of good quality; the text must appear clearly and neatly upon it and both the colour of the printing and the substance of the paper must remain unimpaired. It should also be difficult (or preferably impossible) to erase the text without damaging the ticket. And the substance used should be sufficiently robust to withstand rubbing against other things in one's pocket or elsewhere.

Cardboard. — Edmondson printed the earliest cardboard tickets in 1838. He soon adopted a somewhat thinner cardboard (seven tenths of one millimeter i. e. 0.0275 in.) as he found this strong enough for his purpose and easier to manipulate. Similar cardboard has been used ever since.

So as to reduce cost, a still thinner card was tried in Germany, in Switzerland and in Austria, the idea being that tickets which remained in the passenger's hands but a short time, were less liable to deteriorate. They cost some 16 per cent less than the others, but this was offset by higher printing costs.

And still thinner cardboard has been used in two instances. The first concerns local or suburban lines where the tickets are collected at the outside a couple of hours after having been delivered; the results of these trials were encouraging but not sufficiently so for the Companies to persevere with them. The second instance concerns double or triple Edmondson tickets having control stubs, and which are still in use both in Europe and in America. Without reaching the thickness of our own Edmondson tickets (1), they are nevertheless thicker than the thin German and Swiss card which enables it to be used indifferently both for ordinary and multiple Edmondson tickets.

Railway « cards » are usually printed on cardboard similar to, but a little thicker than, the usual Edmondson's and when it is imperative that they should not be folded, on really thick cardboard: 0.6 mm. (0.0236 in.) on the *Istanbul Metropolitan* (fig. 22), 0.7 mm. (0.0275 in.) for certain *Japanese* return tickets, 1.8 to 2 mm. (0.0708 to 0.0787 in.), for various English season tickets (2), some of which have gilt edges (fig. 23) (3).

(1) Standardised on the basis of twenty four point blank stock (American designation).
(2) *North Eastern Ry.*
(3) *London and North Western Ry.*

SOFT CARDBOARD is used when tickets must be frequently punched or nipped as on road services using the *Bell Punch Co.*'s apparatus which gathers the punched out ticket confettis into the body of the instrument (1), on urban and suburban Companies' multi-journey cards (2), on lines where reels or zigzag strips of tickets are in use (3) and on underground systems where tickets are printed as they are delivered (4).

LONDON & SOUTH WESTERN RAILWAY
No. 705 Available from 24. 4. 19 G
Issued subject to Conditions on other side.
FIRST CLASS SEASON TICKET
CLAPHAM JCT. & WATERLOO
To expire
THREE MONTHS.
Rate £2. 2. 8

Fig. 22. — Thick cardboard ticket (Actual size) — *Constantinople* (Istanbul) *Metropolitan Ry.* — Bilingual countermark.

Fig. 23. — Thick cardboard commutation card — *London and South Western Ry.* — *Validity : three months.* (Red. 3/5).

One occasionally meets with bicolour soft cardboard tickets, the reverse being of a different colour to the front (5).

Parchment was formerly used for free passes (figs. 24 and 25) as frequently as cardboard. It seems to have died out entirely.

Paper tickets must be of good quality, strong, difficult to tear even when crumpled. Special kinds of paper are called upon to meet special requirements.

LINEN PAPER is relatively expensive and its use restricted to season tickets and passes. In Holland, these are made of three layers, cardboard for the outer, linen for the middle one. In the U.S.A. the linen is incorporated in the paper's very pulp.

PELURE PAPER is frequently used for carbon duplicates, and sometimes for blocks of tickets, but we have been unable to find out whether these have any other advantage than the problematical one of taking less room than others. These tickets are made of exceptionally strong paper of very good quality (6).

CARBON PAPER. — So as to avoid the manipulation of carbon paper, which is necessarily a dirty business besides being a lengthy one, tickets are sometimes printed on sheets of paper whose revers

(1) In Great Britain, in many portions of the British Empire, in the Netherlands, and also at Calais, Nantes, Paris *(Ch. de fer Nogentais)*, etc.

(2) Brussels, Antwerp, etc.

(3) Belgian coast lines, *P.O.-Metropolitan* through services, etc.

(4) In London, Paris, Madrid, Moscow, Barcelona.

(5) In Nottingham : recto white, verso pink.

(6) *Strasbourg, Mexico*, tickets of the *Thiriar Works.*

Figs. 24 and 25. — Parchment free passes, 1863 and 1864 (Actual size) — *West Flanders Ry. Co.* and *Turnhout Ry. Co.*

s been submitted to a special carbon eparation (1). In some cases, it is emically treated only along such por- ns as will transmit the guard or con- ctor's writing onto a specially inserted plicate (fig. 26) (2).

Oddments paper. — During the War, kets were printed on the most unlikely ds of paper (Lille, Guadalaxara) any remnants such as playing cards, cigarette paper and such oddments being pressed into use.

« Panmetallophile paper » can be written upon with any piece of metal. To our knowledge, it has only once been used for tickets (Tervueren, 1897).

Safety paper. — Culminating in 1890 or thereabouts, fraudulent and forged tickets were so rife in the U.S.A. that the

1) *Gold Coast Rys., French Railway Companies.*
2) *Eerste Drentsche Stoomtramweg Mij.* (Netherlands).

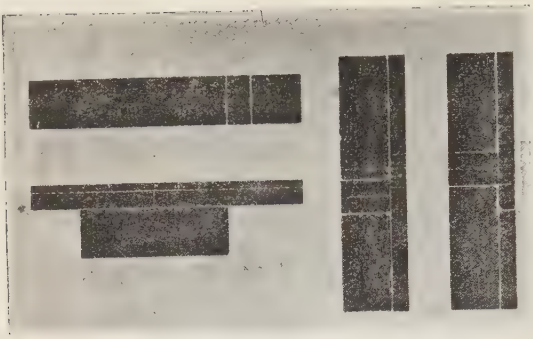


Fig. 26. — Back of ticket specially treated so as to transmit handwriting to a duplicate sheet. (Red. 3/4) — *Eerste Drentsche Stoomtram My.* (First Drent. Steam Tram Co., Netherlands).

professionals who produced them were glorified, as are our own bootleggers and racketeers by a special nickname all their own : they were dubbed ticket scalpers. So as to fight them, the Railway Companies got together and called in Pinkerton and so was evolved a comprehensive system of control. But besides this, every precaution stamp and banknote printers could suggest was also resorted to. These included engraving, multicolour printing, validation signatures, and special kinds of paper. As these are expensive, they are mainly restricted to expensive fare an interline tickets and mostly used in America. Such papers fall into two kinds : chalk surfaced and watermarked (or pseudo-watermarked).

CHALK SURFACE OR DOUBLE SURFACE PAPER (1) takes almost perfect impression which makes it practically impossible t be tampered with. Besides single colou bicolour chalk surface paper, having different colour for either face, is fr quently to be met with, and many colou combinations such as brown and viole yellow and orange, etc. occur (2).

So as to make counterfeiting it mo difficult still, white « reserves » whic may take the shape of repeated desig of the Company's monogram (fig. 27) (are sometimes left.

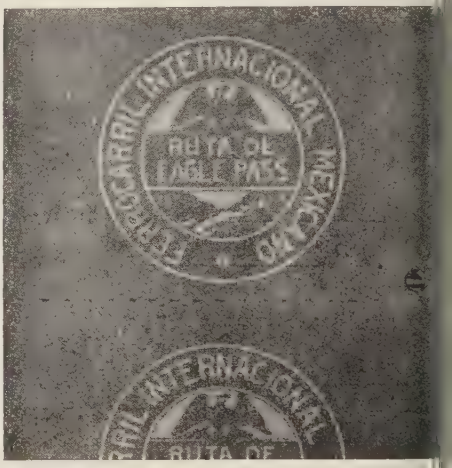


Fig. 27. — Back of double chalk surface tick showing white monogram on colour ba ground (Red. 3/4) — *F. C. Internacio Mexicano* (Mexican International Ry.) Bilingual ticket in Spanish and in Engli

WATERMARKED PAPERS. — We gro two sets of papers under this headi

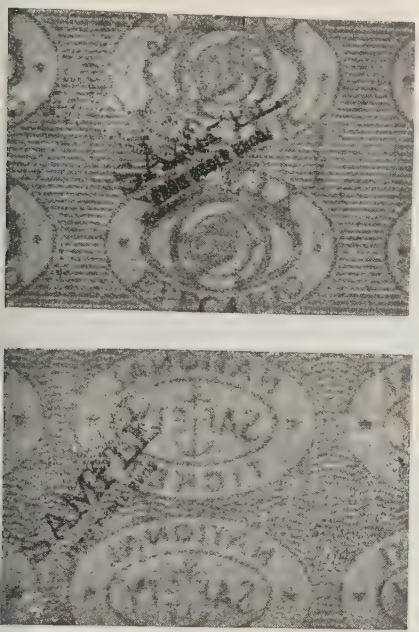
(1) American *Pullman Co.*'s tickets.

(2) Here are several other instances :

yellow and orange, *Canadian Pacific Ry.;*
yellow and green or pink and azure, *Canadian National Rys.;*
green and orange, *Algoma Central and Hudson Bay Ry.;*
grey and orange, *Missouri, Kansas and Texas Ry. of Texas;*
brown and emerald green, *Tuskegee R. R.*

(3) *Ferrocarril Internacional Mexicano* (Mexican International Ry.).

ough, as a matter of fact, the second
ie only has real watermarks.
The first of them, which we shall dub
pseudo-watermarked paper » reprodu-
s a design in two shades of the same
lour, through its entire depth; it exists
entically on either face and the thick-
ss of the paper. It extends over its
tire surface.



s. 28 and 29. — Pseudo-watermarks show-
ng parallel straight or wavy lines and
vals breaking into them. (Red. 1/2) —
ack of paper band-tickets.

The most usual design consists of parallel wavy lines, broken into at regular intervals, either by the manufacturer's name or the Company's monogram or crest. Such is the « Rand MacNally and Co. Safety paper » (fig. 30) (1), « King's Head Safety Paper » (2) and the « National Safety Paper » (fig. 29) (3) and, as Company's names when the paper has been specially made for them, the *Manila Railroad Co.*'s *M. R.* (Philippines) in a circle, the *Southern Pacific*'s or the *New York Central Lines*' in an oval (fig. 32).

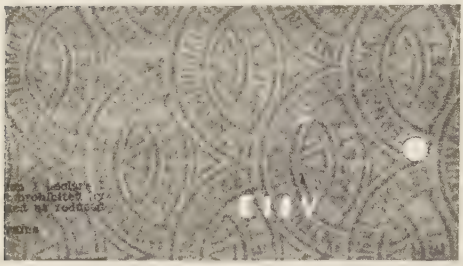
In other instances, straight parallel lines are broken into such as by ovals showing the picture of a car surrounded by the words « Electric Safety » (fig. 28) (4) or « Phelps protection paper » in a double circle (5).

But parallel lines are not always to be found. The « Universal Safety Paper » repeats its name in a rectangle amid a series of swastikas (6), and several railway Companies are satisfied with the simple repetition of their initials, as the Brazilian *Corcovado Ry.* with the *S.P.R.L. and P.* (7) of the owning Company, the Central American *F. C. del P. de N.* (fig. 34) (8) and so on, and the « International Safety Ticket » paper (9) simply repeats its name in a complicated design.

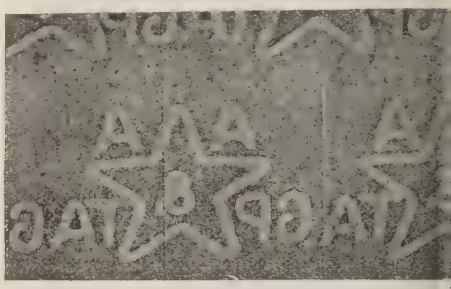
The same principle of pseudo-watermarks is used for Australian interline (through) tickets (fig. 35).

) *Southern Pacific Ry.*
) *East Broad Top. R. R. and C. Co.*
) *The Dayton and Troy Electric Ry. Co.*
) *The Detroit, Monroe and Toledo Short Line Ry.*
) *The Pacific Great Eastern Ry.*
) *The El Oro Ry. and Mining Co. Ltd.*
) *Rio Light and Power Co.* (Brazil).
) *Ferrocarril del Pacifico de Nicaragua.*
) *Pennsylvania Railroad Co.*

Fig. 30. — Pseudo-watermarked paper (Red. 3/4) — *Southern Pacific* — Last page o block of sheets each containing a number of strip-tickets — Date of availability — Suburban services.



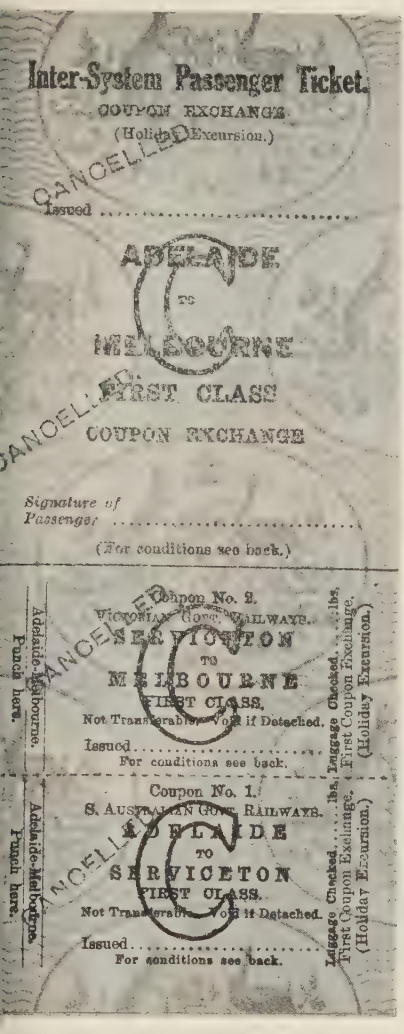
Figs. 31 and 32. — Pseudo-watermarked paper. (Red. 1/2).



Figs. 33 and 34. — « Association T Paper » — Watermarks and pseudo wa marks. (Red. 1/2).

Real watermarks, which would seem to be modified forms of the previous ones, appeared about 1890. Their somewhat crudely drawn stars, with the paper manufacturer's initials *(C.P.T.A.)* around them (fig. 33) (1), slightly discolou the paper and showed in a lighter hue grey or a darker background. The « sociation Ticket Paper » was put on market about this time (fig. 34). It

(1) *New York and Pennsylvania Railroad Co.*



35. — Australian pseudo-watermarked per — Interline ticket-band with detachble coupons — Exchange ticket — Category : holiday excursion — Skeleton letr overprint.

ible as embodying simultaneously kinds of watermarks : the « pseudormarks » with their wavy lines and s containing the name of the paper the large stars with their capital let-

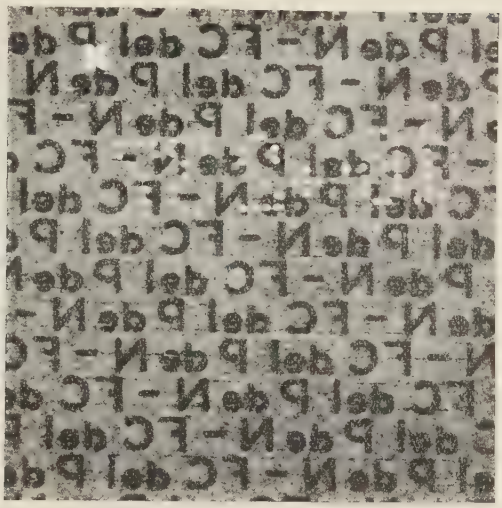


Fig. 36. — Back of pseudo-watermarked paper ticket. (Actual size) — *F. C. del Pacifico de Nicaragua* (Nicaragua Pacific Ry.) — Dated by perforation.

ters, and which have been much improved since they came into use.

Early tickets, such as the *Chicago, Rock Island and Pacific Ry.*'s printed in 1910 on the doubly watermarked paper, looked as if the two sides were differently coloured : they appeared to be green on a lighter green background at the back and on a pinkish one in front. The watermark proper is invisible in front, clearly distinguishable by transparency and of the same pinkish hue at the back. In later tickets, the watermark is indistinguishable on both sides but easy to see by transparency.

Applying principles similar to the Bank of England's, the *American Association of General Passenger and Ticket Agents* adopted, in 1907, at the Washington Convention, a standard pale green « Association Ticket Paper » which was alone to be used for interline tickets.

Special paper manufacturers sent this

paper directly to the ticket printers who delivered a written guarantee stating that they had used the paper exclusively for the printing of railway tickets.

The use of this paper, which had been restricted to interline tickets, has gradually been extended to other categories and besides the original pale green, other coloured papers such as pink, beige, olive, grey, white, emerald, blue and others, have been produced.

In Europe, watermarked paper is exceptional. The Belgian War Dept.'s pre-War ticket orders were printed on it (fig. 37).

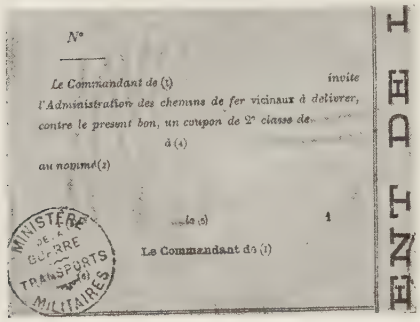


Fig. 37. — European watermarked paper. (Red. 1/2) — Ticket order issued by Belgian War Dept.

GRANITE PAPER is used in Japan and allied countries.

Metal is or has been used for countermarks, exchange tickets, passes and season tickets.

These metal tickets were generally circular in shape, 25 to 35 mm. (1" to 1 3/8") in diameter and were to be found in the British Isles, in India, Australia, Canada and the U.S.A., also in France, the Argentine, Chile, etc.

Figs. 38 and 39. — Zinc and brass checks of the *Constantinople Metropolitan Ry.* — Bilingual. (Actual size).

Fig. 40. — Ivory free pass
(Actual size) — Spanish *Norte* Railway; about 1860.

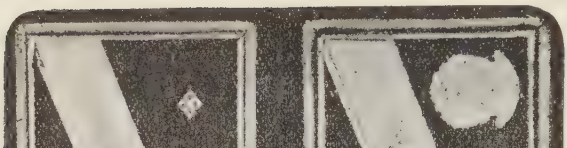
Fig. 41. — Manchester.
Fig. 42. — Aberdeen.
Fig. 43. Montevideo.
Fig. 44. — Valparaiso.

Figs. 41 to 44. — Celluloid and Xylonite tokens and checks.
(Actual size).

Bronze first appeared for the *Leicester nd Swannington Ry.'s* tickets in 1832 (1) nd was next used for short-period season tickets, longer ones being of silver, annuals and director's passes, of gold.

Other metals, brass, frequently (fig.

(1) This octagonal token, 35 by 35 mm. (1 3/8" × 1 3/8"), bore very little text : the Company's initials and a serial number only (see fig. 258).



Leather covers with gilt lettering and coat of arms.

Fig. 45. — Cover in two colours — *Sorocabana Ry.* (Brazil) — Category : Senator's free pass.

Fig. 46. — Complimentary pass — *Natal Govt. Rys.*
Inside, a folder with photographic views of places of interest.

38), and more rarely zinc (fig. 39) (1) were also used for countermarks and certain categories of tickets.

Bone and ivory (fig. 40) have been used for passes and exchange tickets.

Xylonite and celluloid tokens, all of them 22.5 mm. (7/8") in diameter, appeared in the late eighties. They were of different colours according to class and value and appear to have been first used in 1889, by the *L. C. C. Tramways* then in Manchester (2) and Glasgow until 1901 (3), at Aberdeen (4), also by the *F. U. de Valparaiso* (5), the *Tranvia de la Union*, of Montevideo (6), and others (figs. 41 to 44).

Leather, percaline and other bookbinding materials serve for season ticket covers and for passes, a printed sheet which is the ticket proper being gummed or slipped in (fig. 46). Leather covers are sometimes bicoloured, the lettering being usually in gold and lately, so as to economise, in black.

CHAPTER III.

THE SHAPE OF TICKETS.

Most tickets are rectangular, with standardized dimensions. Edmondson type tickets have been unchanged since their inception and are still produced to 30 by 57 mm. (1 7/32" × 2 9/32") on the Continent, and to 1 3/16" by 2 1/4" and a thickness of 1/32" in the British Isles.

(1) Probably in Istanbul only.

(2) As elsewhere, these tokens had the Corporation's coat of arms on the obverse and the value (in this case, 1/2 d. blue and 3/4 d. orange) on the reverse.

(3) The 1/2-d. tokens were blue, the 1-d. ones, white.

(4) The 3/4-d. tokens were of a greenish blue.

(5) These tokens were much thicker than the others, with a serial number poorly scratched on. They bore a class designation.

(6) In black celluloid. On the obverse, appeared a tramcar, on the reverse a numeral : 10 (centavos). This was therefore more a ticket than a token.

The *International Railway Transport Committee*, whose seat is in Berne, has also fixed the dimensions of other kinds of tickets :

Books of coupons	88 by 125 mm.	(3 15/32" × 4 29/32") ;
Books of combined coupons, cover	100 by 142.5 mm.	(3 15/16" × 5 39/64") ;
Books of combined coupons, coupons	100 by 140 mm.	(3 15/16" × 5 1/2") ;
Group tickets and Transport bulletins.	About 210 by 300 mm.	(8 1/4" × 11 13/16").

Further dimensions have been standardized in Germany :

Blank cards, overall	85 by 110 mm.	(3 11/32" × 4 11/32") ;
Blank cards, printed matter	70 by 100 mm.	(2 3/4" × 3 15/16") ;
Commutation cards	70 by 46 mm.	(2 3/4" × 1 13/16").

Other tickets often conform to these dimensions.

American band-tickets are about 72 mm. (2 53/64") wide (fig. 52) whatever their length, which reaches as much as 7 or 8 feet.

The size of polygonal, oval, or circular tickets is variable. Before describing them, we shall examine rectangular tickets in some detail.

Edmondson tickets. — In spite of the progress of transport, due to railways superseding mailcoaches, the establishment of the contract between the Company and the passenger had remained unchanged. It was a slow and complicated affair until a small stationmaster of Milton (1) on the *Newcastle and Carlisle Ry.* (2) invented the ticket which bears his name, in 1836. Two scraps of paper, the railway ticket and the postage stamp, the first due to Edmondson (3) the second, to Rowland Hill, were going to hold a considerable place in the World.

Edmondson's ingenious idea, from which his invention proceeded, applied a principle whose importance is not inferior to the inventions that put it into practice. He was the first to issue impersonal tickets, thus doing away, at one fell sweep, with the antiquated system which obliged the clerks to write out, by hand, both on every ticket and on their counterfoil, everything relating to the passenger and to his journey (figs. 47 and 48). Edmondson identified the railway's patrons as passengers by the simple means of dating and serially numbering his tickets.

He first substituted cardboard to paper which alone had been used up to this time. At this period, he still used to fill in all necessary information by hand, adding a serial number whose original function was to regulate the order of passenger's admission to the trains; these early tickets, somewhat smaller than the present ones, were undated (fig. 49). He then found it convenient to reduce clerical labour and printed the text by means of a hand machine, solely filling in the number by hand (fig. 50). Owing to the success which attended these early trials, he further improved his machine and, in 1838, produced the first tickets of the present type (fig. 51) whereon even the serial number was printed. The type was fixed in a wooden block and inked; and

(1) Now Brampton Jn.

(2) This railway is now a part of the *London and North Eastern Railway*.

(3) Thomas Edmondson was born in Lancaster on 30 June 1792, and was first articled to a cabinet maker. He died at Broughton, Manchester, on 22 June, 1851.

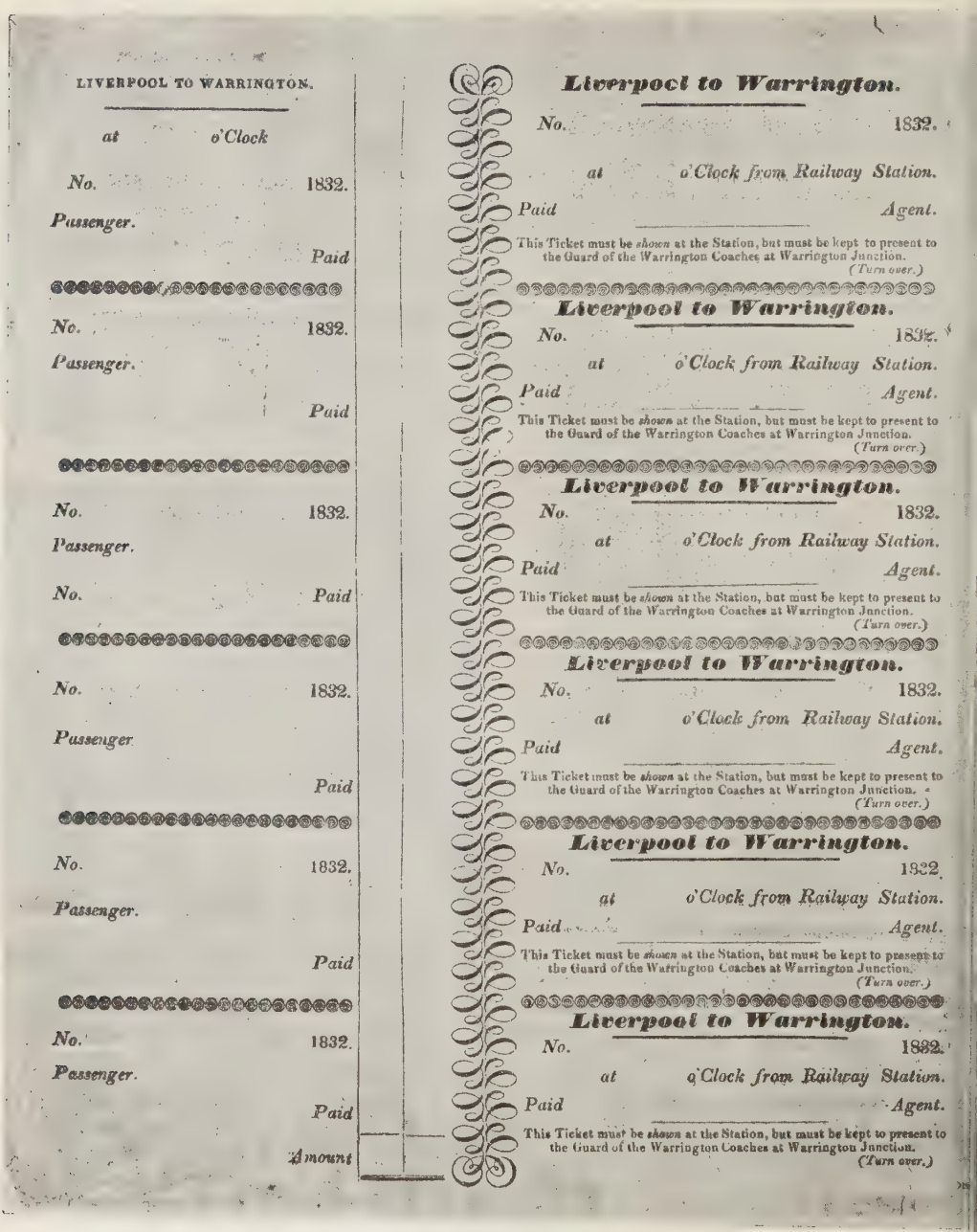


Fig. 47. — Complete sheet of old *Liverpool and Manchester Ry.* blank tickets, 1832. (Red. 3/4) — Further notices are printed at the back of the ticket.

Origin and development of Edmonson tickets.

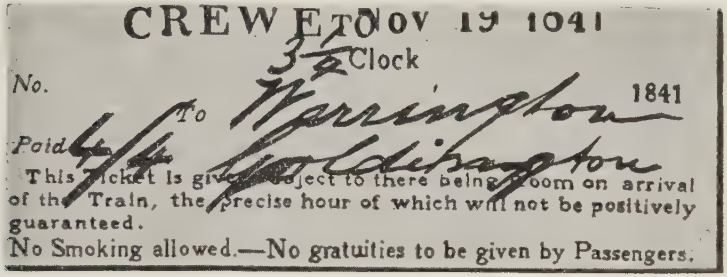
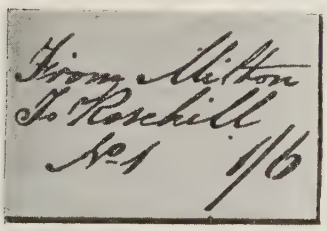
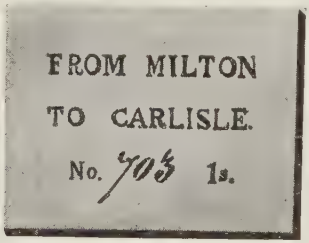
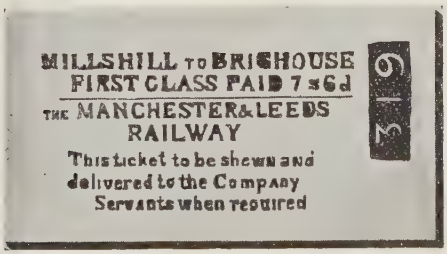

CREWE TO
NOV 19 1041
3 ½ Clock
No.
To Warrington
1841
Paid 4/4
Goldington
This Ticket is given subject to there being room on arrival of the Train, the precise hour of which will not be positively guaranteed.
No Smoking allowed.—No gratuities to be given by Passengers.

Fig. 48. — Old blank paper ticket (Actual size) — Notices to passengers stating the Company declines any responsibility as to the times of the trains or there being room in the carriages — Various prohibitions.





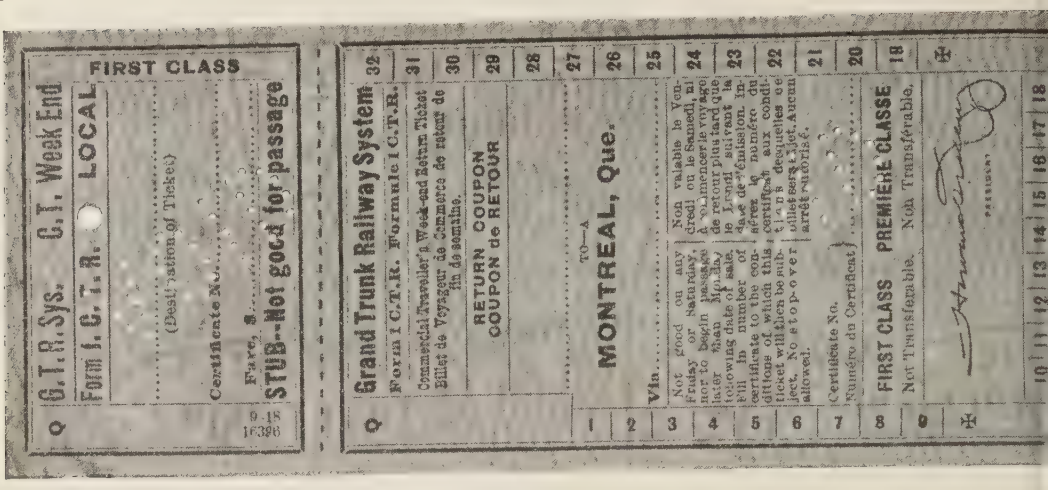


The first Edmondson tickets (Actual size).

Fig. 49. — Card ticket with manuscript data in Edmondson's handwriting — *Newcastle and Carlisle Ry.*

Fig. 50. — One of the earliest cardboard tickets to have been printed with Edmondson's handpress — Serial number filled in by hand — *Newcastle and Carlisle Ry.*

Fig. 51. — Earliest Edmondson standard size ticket — *Manchester and Leeds Ry.* (1838) — With notices at back of ticket.


FIRST CLASS
G.T.R.Sys. C.T. Week End
Form I.C.T.R. LOCAL
(Destination of Ticket)
Certificate No.
Fare, $
STUB--Not good for passage
9-18
16396
Grand Trunk Railway System
Form I.C.T.R. Formule I.C.T.R.
Commercial Traveller's Week-end Return Ticket
Billet de Voyageur de Commerce de retour de fin de semaine.
RETURN COUPON
COUPON de RETOUR
TO—A
MONTREAL, Que.
Via
Not good on any Friday or Saturday nor to begin passage later than Monday following date of sale. Fill in number of certificate to the conditions of which this ticket will then be subject. No stop-over allowed.
Non valable le Vendredi ou le Samedi, ni à commencer le voyage de retour plus tard que le Lundi suivant la date de l'émission. Inscrire le numéro du certificat aux conditions duquel ce billet sera alors soumis. Aucun arrêt autorisé.
Certificate No.
Numéro du Certificat
FIRST CLASS PREMIERE CLASSE
Not Transferable. Non Transférable.

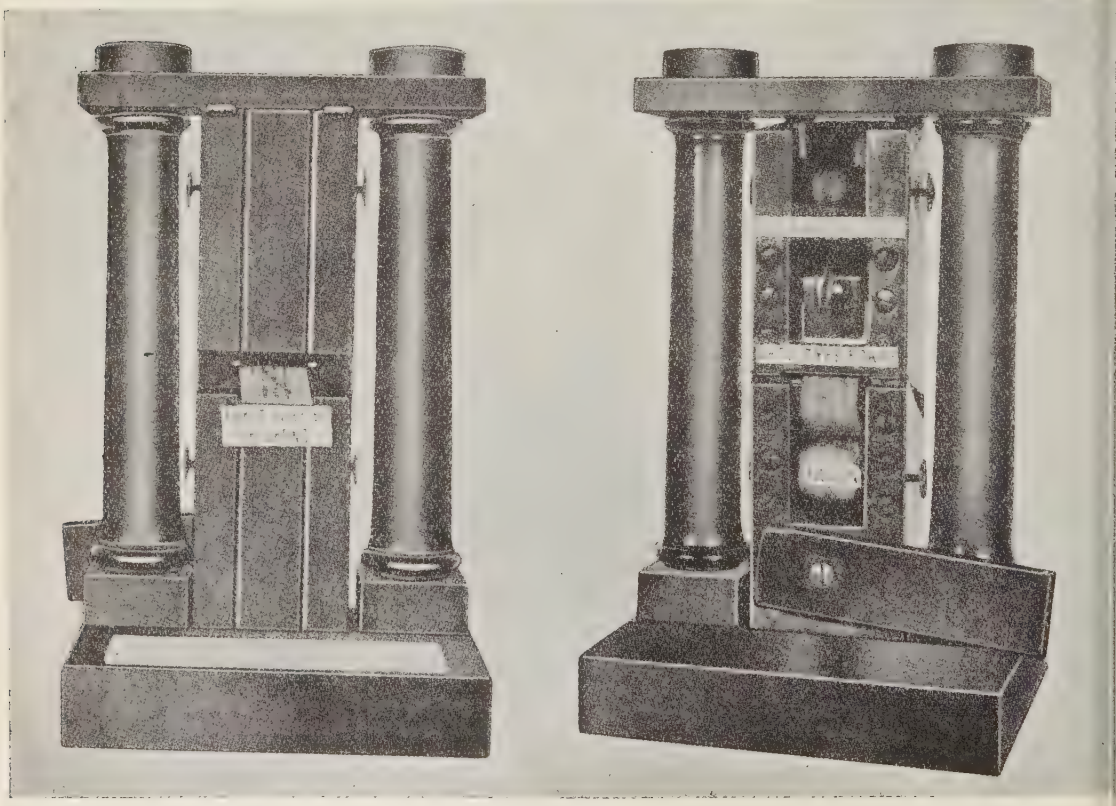


Fig. 53. — Early Edmondson printing presses.

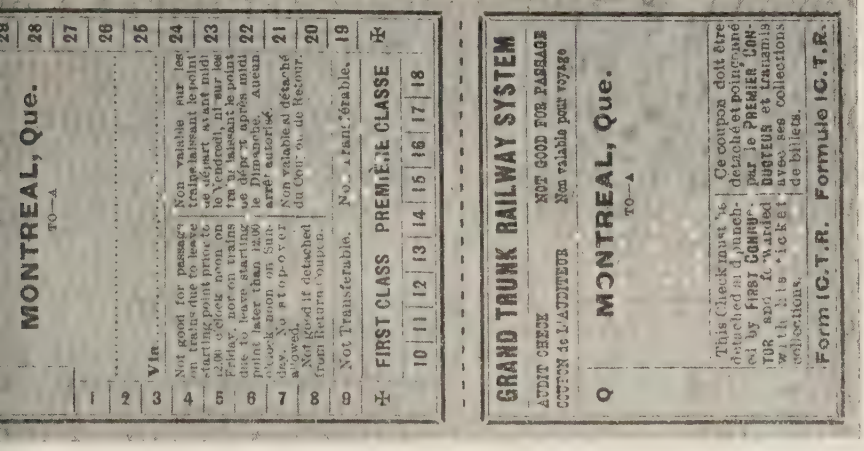


Fig. 52. — Canadian paperband ticket (Red. 3/4) — *Grand Trunk Ry. System* — Return ticket with audit checks (control coupons) — Bilingual : English and Canadian French — Fixed destination; blank departure station; President's signature — Pseudo-watermarked paper.

the impression transferred by means of a blow from a mallet. The ticket was then cut from the strip with a pair of scissors. Figure 51 shows one of these early tickets printed for the *Manchester and Leeds Ry.*

Edmondson continually improved his machine. He placed his type in formes as was done for handbills, and by turning a handle, actually printed the ticket. Cardboard blanks were thrown into a hopper so that the lowest of them enter-

Early tickets printed by Edmondson (Red. 4/5).

Fig. 54. — Single ticket — *London, Brighton and South Coast Ry.*

Fig. 55. — Single ticket — *Midland Ry.* — Priced.

Fig. 56. — « Return » ticket — *Great Western Ry.* — With station number (38) and price added by hand.

Fig. 57. — Single ticket — *Pembroke and Tenby Ry.*

ed a slit 1 1/4" wide (as at present) (1). The printing took place and the consecutive numbering by the agency of four wheels automatically rotated by a pusher as the forme rose and fell. Each wheel had the ten digits cut on the edge of it and every time the unit wheel moved round once, a stud on it came in contact with a projection on the tens wheel and advanced it one figure. The tens wheel similarly moved the hundreds wheel and the hundreds, the thousands so that, without interruption, 10 000 tickets from 0 to 9999 inclusive could be printed with one setting of the machine (2).

When this was done, the ticket was driven forward onto a stage by the next blank, as the latter was propelled into place somewhat as a shuttle is thrown across a loom, and it then dropped, ready for use, into another hopper (figs. 54 to 57).

Edmondson invented a number of necessary adjuncts : counting machines, ticket racks, dating presses and rounded up the whole by ticket destructors which ended the life of the tickets before they were again turned into paper pulp.

At first, tickets were taken, as needed, from the top of the packets; they rested on springs which pressed them upwards. Nowadays, the lowest ticket is sold first.

The movable dating forme was at the top and back of the press. The pressure exerted in inserting a ticket in the front of the machine determined the rotation of a ratchet wheel situated in the upper part, which drew up an inked ribbon previously coiled in the bottom of the machine. The dating forme simultaneously pressed the ribbon on the ticket thus printing it (3). The ribbon's transmission was further improved by Edmondson who brought out new printing and dating presses in 1848.

Edmondson's chiefs do not appear to have grasped the importance of his inventions and only allowed him to use his machines in a few of the Railway's stations. The *Manchester and Leeds Ry.* officials were more go ahead and employed Edmondson but he only stayed a few months with them and thenceforward gave all his time to exploiting his inventions (4). He took Muir into partnership and supplied his machines to a

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(1) Some of this information is taken from an article published by Mr. John Partington, chief accountant and controller of the *London and North Western Ry.*, in the « Railway Magazine », in 1899.

(2) This description is also reproduced from the article we have quoted.

(3) This description is drawn from an article signed D. V. L., which appeared in the September 1933 number of the « Great Western Magazine » to whom we are also indebted for permission to reproduce (fig. 53) the back and front views of Edmondson's early ticket-dating press as used by the *Great Western Ry.*

(4) In 1840, Edmondson fixed his abode in Manchester and entrusted the commercial side of his business to his brother Joseph. But whilst he was an excellent cabinet-maker, he was a poor artisan in metals so from April 1842, he ordered all metallic pieces from Muir. His affairs prospered to such an extent that no later than June 22 Muir asked Withworth, for whom fe worked, for permission to give his whole time to Edmondson's machines and this was granted him. Improvement patents were then taken jointly in the name of both partners.

They soon moved to a new Works at Miller's Lane in Salford and, when it again became necessary to enlarge the premises, to Strangeways (Manchester) on Lord Ducie's land and on the very site where, later, the Britannia Works were erected. But with the growth of the business, the presses which had so ably fostered it, sunk to the rank of a simple Department.

Muir died in Brockley on 15 June, 1888.

Figs. 58 and 59. — First standard Edmondson tickets — *Belgian State Rys.* — Availability given in leagues (the Belgian league is 5 km., not 4 as is the French) — Price stated — Serial number in skeleton numerals — Company's coat of arms. (Red. 4/5).

umber of railways. Edmondson died ithin a few days of his 60th birthday.

The contracts Edmondson signed with e Railway Companies registered the le of everything that was required for e printing of the tickets, presses, print- g formes, case of type, ribbons, ink, c. for a lump sum of £ 150 and granted licence for their use and for the spe- alised system of keeping accounts relat- g thereto. Edmondson's charges were a mileage basis. For a railway thirty iles long, the cost was £ 15 a year, plus 5 per annum for every additional five iles of line. The Directors of the *Great estern Co.* adopted Edmondson's inven- n in April 1845, paying for the pri- ege a sum of £ 75 a year for its use the first 300 miles of line, plus 5 sh. r annum for each subsequent mile (1). nce then, whereas the ticket has attract- ever more text, its principles have re- ined unchanged.

SIZE. — To Edmondson appertains the rit of having standardised the ticket's e from the outset. But the same does t apply to the text nor to the colours, st Companies having long printed kets as suited them; in spite of this, extreme diversity of those early ti- s has gradually given place to some sort of order. Independant local lines were the first to adopt the rules of their larger brothers and in some countries, such as Switzerland and Germany, all the Railway Companies soon used the same tickets which no longer differed from one to the next.

More recently, the *International Union of Railways* has done much in the same spirit, just as, previously, the German *Verein* had done for its adherents and corresponding Companies.

Since very early times, return tickets comprised two portions, one of which was withdrawn at the expiration of the outward and the other, of the inward journey.

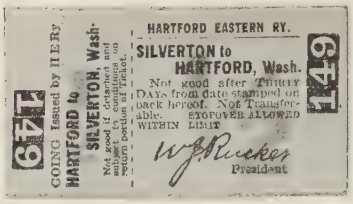
But this rule was not absolute by a long way.

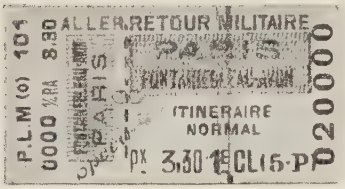
The dimensions of the return portion varied and, instead of the more usual 28.5 mm. (1 1/8"), was frequently reduced to 15 or 20 mm. (19/32" or 25/32") only (figs. 60 to 62).

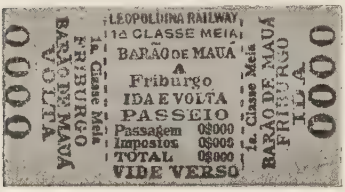
Fixed tickets often have a stub for accounting purposes and, in the case of blank tickets, this entails a lengthening of the ticket from 57 to 81 or 83 mm. (from 2 1/4" to 3 3/16" or 3 17/64") (figs. 63 and 64).

MULTIPLE EDMONDSON TICKETS, which

1) From D.V.L.'s article, previously quoted.


HARTFORD EASTERN RY.
SILVERTON to
HARTFORD, Wash.
Not good after THIRTY DAYS from date stamped on back hereof. Not Transferable. STOPOVER ALLOWED WITHIN LIMIT
W. J. Rucker
President
SILVERTON to HARTFORD
HARTFORD to SILVERTON
GOING Issued by H E Ry
149





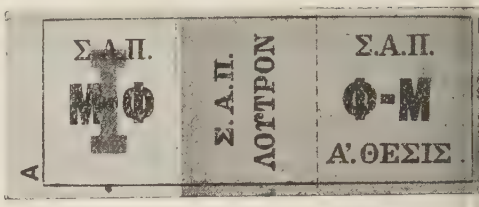
Return Edmondson tickets with different-size. return portions. (Red. 4/5).

Fig. 60. — *Hartford Eastern Ry.* (U.S.A.) — Half-price-ticket blanks previously overprinted 1/2 in blue (for children) — Dated at back — Availability, 30 days.

Fig. 61. — French *P. L. M. Rys.* — Showing route to be followed — First printing in green of the word « aller » (going) and safety backgrounds; second printing in black — Category : military.

Fig. 62. — *Leopoldina Ry.* (Brazil) — Three-portion ticket with central stub, right outward and left inward portions — Shows what part of price goes to the Railway Company and to taxes — Category : half-price holiday ticket.

usually have a control coupon, are of several times the standard size. They comprise 2, 3 or even 4 parts, each of the usual size and joined together (or more accurately separable) either along the smaller or the longer side of the ticket.



Long-shaped Edmondson tickets. (Red. 4/5

Fig. 63. — Return blank ticket with contr stub — *Belgian National Rys. Co.* — I ternational services.
As this ticket is issued according to the I ternational Convention's stipulations, bears an interwoven « C. I. » monogram.

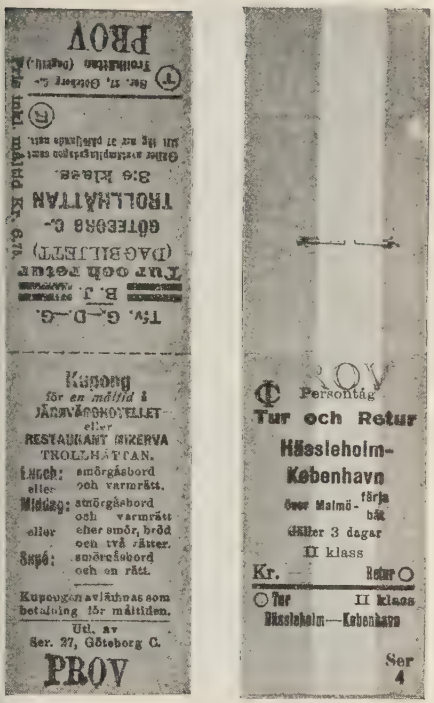
Fig. 64. — Return ticket with centre stub — *Hellenic Rys.*

They are in use in Switzerland, in Ge many, in the States and elsewhere.

They are usually printed in a sing printing on the same face of the car board. But in Sweden, the control co pon of return tickets is printed on t other side of the card so that, when fol ed, the printing reads, as on the tick itself, on the obverse side (fig. 66). E ropean multiple tickets are usually n nocoloured; in America, bicoloured a in Japan, of two shades of the same lour (fig. 69).

Swiss return tickets have no deta able portion; double tickets joined alo the smaller side, have a control coup for checking which route, among seve has actually been followed. In some ses, this coupon comprises two portio one of which corresponds to either rection of the journey (fig. 68) (1).

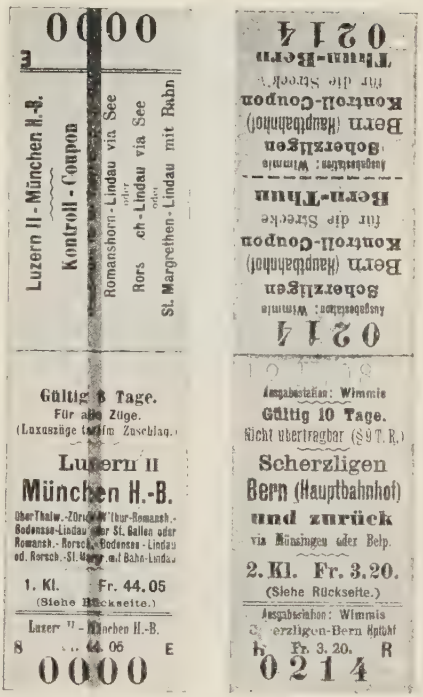
(1) *Swiss Federal Railways.*



Edmondson double tickets — *Gävle Dala Grängesberg Ry.*, Sweden. (Red. 4/5).

ig. 65. — Return ticket with meals control-coupon.

g. 66. — Return booklet of tickets including ferryboat coupon — Impression on opposite sides.



Edmondson double tickets. (Red. 4/5).

Fig. 67. — International journey, issued by the *Swiss Federal Rys.* with control-coupon for collection by either the steamboat cross services or by rail around the lake.

Fig. 68. — Return ticket, *Swiss Federal Rys.* with control coupon comprising two portions, one for collection each way, the ticket being available by the alternative *Federal Rys.* or the *Berner Alpenbahnen* Bern-Thun lines.

fferent system is used in Germany here they have or had triple tickets hose first portion is a return ticket, the cond one a control coupon for the inard, and the third, a control coupon r the outward journey (1). In the S.A., there are triple tickets of this d comprising six half tickets : three of them for successive sections of the outward trip and three for the return (2).

Control-coupons without travelling validity are much used in America, even for single tickets; in this case, they are joined along the smaller side.

(1) Endigen-Freiburg journey with control coupons for travelling via Riegel or via Bal-ngen-Gottenheim.

(2) *Evansville and Ohio Valley Ry. Co.* and third section of journey by the *Crescent avigation Co.*

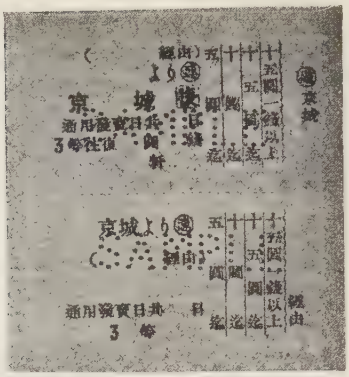


Fig. 69. — Double ticket of the *Manchukuo Rys.* (Red. 4/5) — The safety backgrounds of the two portions are printed in different shades of the same colour.

On the other hand, Canada can show a number of multiple tickets joined (like all Japanese ones) along the longer side (fig. 70). They all have the travelling portion (or portions in the case of return tickets) in the centre, a control-coupon for the booking clerk on the left and another, for the passenger after the inspector has collected the ticket (or tickets) proper. This « receipt » enables him to justify accommodation or journey paid for (1).

The *Pennsylvania R. R. Co.* also has quadruple tickets (fig. 71), but these are joined along the smaller side, three portions serving as check coupons, the fourth only being a fast train extra-fare ticket. The first portion is a stub coupon which the booking clerk retains, the second is an order for repayment in case of the train's late arrival; the third is the passenger's supplement and the fourth, an identification receipt which he retains so as to prove, eventually, when requesting reimbursement, that he is the original buyer of the ticket.

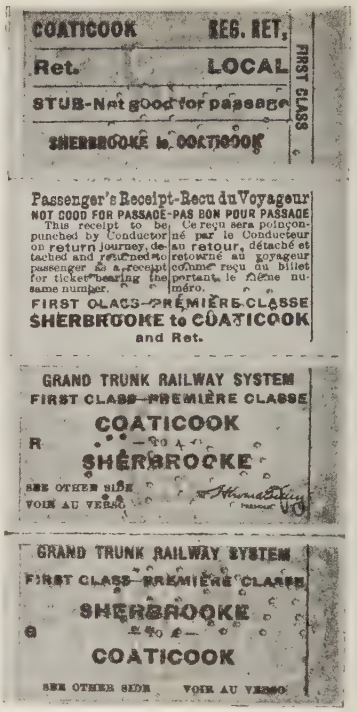

COATICOOK REG. RET.
Ret. LOCAL
STUB-Not good for passage
SHERBROOKE to COATICOOK
FIRST CLASS
Passenger's Receipt-Recu du Voyageur
NOT GOOD FOR PASSAGE-PAS BON POUR PASSAGE
This receipt to be punched by Conductor on return journey, detached and returned to passenger as a receipt for ticket bearing the same number.
Ce reçu sera poinçonné par le Conducteur au retour, détaché et retourné au voyageur comme reçu du Billet portant le même numéro.
FIRST CLASS-PREMIÈRE CLASSE
SHERBROOKE to COATICOOK
and Ret.
GRAND TRUNK RAILWAY SYSTEM
FIRST CLASS—PREMIÈRE CLASSE
COATICOOK
SHERBROOKE
SEE OTHER SIDE
VOIR AU VERSO
GRAND TRUNK RAILWAY SYSTEM
FIRST CLASS—PREMIÈRE CLASSE
SHERBROOKE
COATICOOK
SEE OTHER SIDE VOIR AU VERSO

Fig. 70. — Edmondson quadruple ticket *Grand Trunk Ry. System* (Canada) — R turn ticket including control stub and p senger's receipt — Bilingual — Safe background. (Red. 4/5).

TYPES OF EDMONDSON TICKETS. — We v call « horizontal side », the longer o and « vertical side », the shorter one.

Formerly, the text of single Contin tal tickets was parallel to the smal side : they were thus vertical ticke whereas British, Swiss, and Central Eu pean tickets were horizontal. Retu tickets were the contrary.

An interesting case showing the rep cussion of operating methods on ticke ing has just occurred in Switzerla This is one of the few European co tries where access into the stations is f

(1) *Grand Trunk Ry. System.*

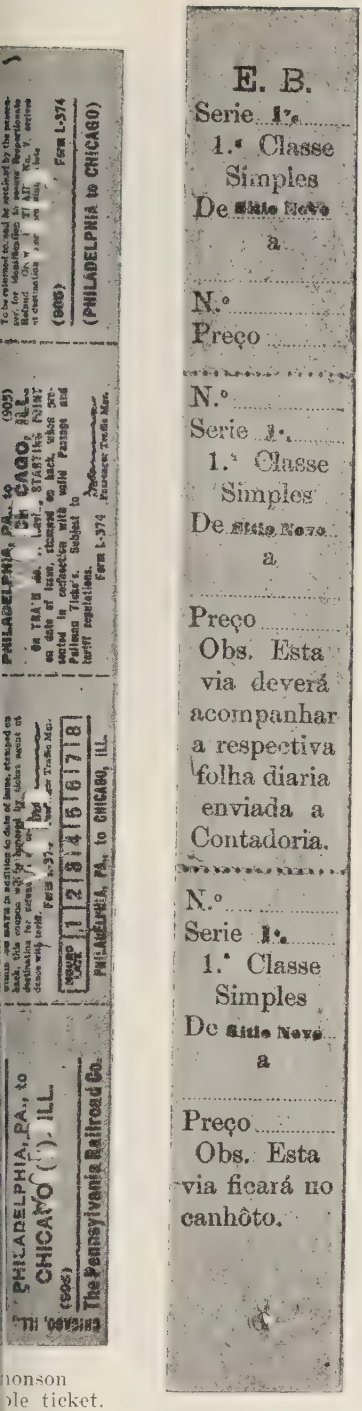
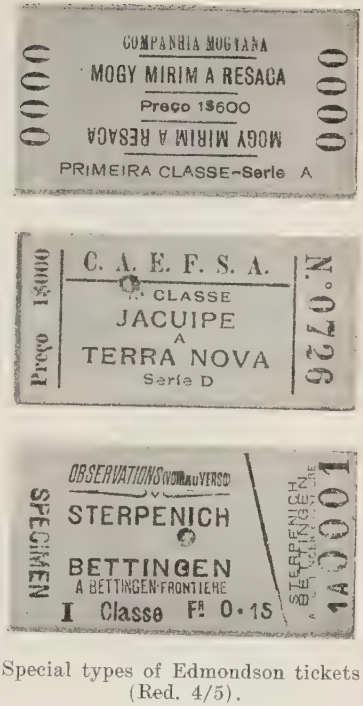


Fig. 71. — *Pennsylvania R. R. Co.* extra fare ticket including refund order for total or partial reimbursement in case of late arrival — Agent's stub and identification coupon — Parameter : number of hours late.

Fig. 72. — Brazilian triple ticket with two control coupons.



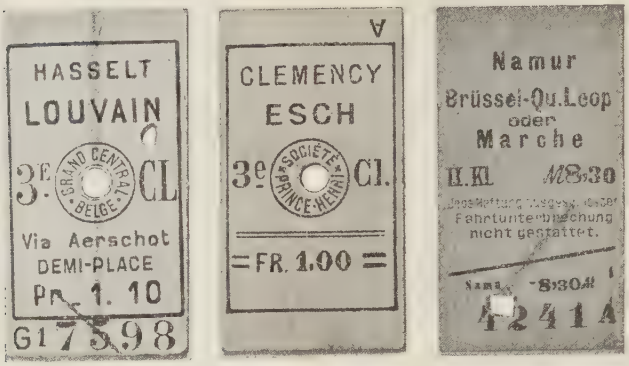
Special types of Edmondson tickets (Red. 4/5).

Fig. 73. — *Mogyana Co.* (Brazil) — Fixed journey with letterpress facing both upwards and downwards.

Fig. 74. — *Saõ Amaro Ry.* (Brazil) — Price printed perpendicularly to the rest of the text.

Fig. 75. — *Belgian State Rys.* — Old Belgian ticket of German type, available on a 1 200-metre frontier section.

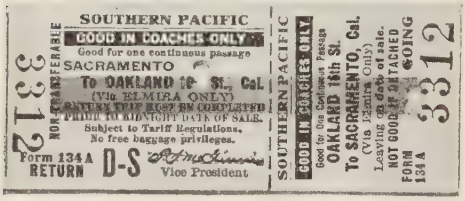
and no platform tickets are necessary or issued. But passenger tickets must be checked and as all trains are corridor trains, this is easily accomplished in the course of the journey. Inspectors frequently check the tickets which are clipped each time and this happens so often that important information is sometimes clipped out. For this reason, no further single horizontal tickets have been printed since last year and as return tickets have always been vertical, all Swiss Edmondson tickets are so now.

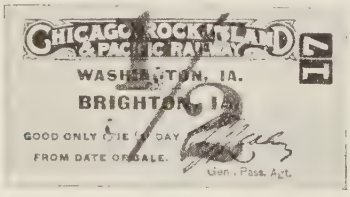


Types of tickets (Red. 4/5).

Figs. 76 and 77. — Company's name inside double circumference.

Fig. 78. — German type ticket issued in Belgium during the German occupation of the country.





American Edmondson tickets. (Red. 4/5).

Fig. 79. — Return ticket with text running both ways — *Southern Pacific.*

Fig. 80. — Half price ticket, available one day only — *Chicago, Rock Island and Pacific Ry.* — Company's name and serial numbers printed with negative type (white on black background).

Some of the text of certain Brazilian tickets is reversed (« tête-bêche ») in regard to the rest (fig. 73); this is done so as to be able to read it without having to turn the ticket round. As a matter of fact, the text of many tickets is printed in t directions which are perpendicular each other. Thus the serial numbers horizontal tickets are printed vertica along the smaller side, as is also the jo ney on German tickets (fig. 75), and price on the *Companhia E. F. Sao Am* (Brazil) tickets (fig. 74).

Types of tickets are usually pretty milar in each country, as in Belgi (figs. 76 and 77), France and elsewhe But intercompany tickets are frequen printed to the type adopted by the fore Company (figs. 75 and 78).

American Edmondson tickets are able by the excellence of their print and the quality of the material us They bear a few notices to passeng the facsimile of the general passen agent's signature and the Company's me, which latter is far from being us on the Continent. On the other ha the price, which always appears with is omitted. They are stamped and da at the back.

American return tickets comprise separable portions; they are usually tical tickets whose portions are som

Edmondson American double tickets.
(Red. 4/5).

ig. 81. — Single ticket including one whole and two half coupons, the latter with text perpendicular to the former's — *Union Traction Co. of Indiana.*

ig. 82. — Two-coupon return ticket bearing the distinctive bars (one for the outward, two for the return journey), standardised by the *United States Railroad Administration* in whose hands the operation of the *Southern Pacific Railroad* was then vested.

es reversed; occasionally, the text of e going portion is parallel to the smalr side, and that of the return portion, rallel to the other (fig. 79). Half-fare hildren's) tickets are printed on blank rds bearing in red or exceptionnally, blue, the figures « 1/2 » (fig. 80).

Both single and return tickets are ised either with or without a ticket stub, mm. (25/64") high.

Multiple tickets are not exceptional;

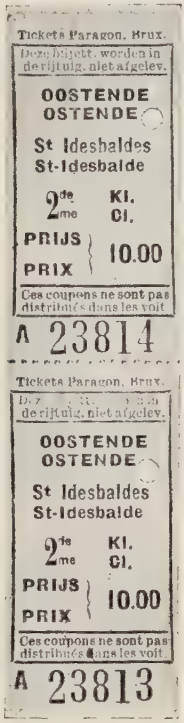


Fig. 83. — Reel tickets *(Paragon Printing Works)* — *Belgian National Light Rys. Co.* Soft cardboard — Not sold in the cars.

their letter-press is either parallel to the longer side (fig. 82), to the smaller one, or to different sides on each of the coupons (fig. 81).

REELS OF EDMONDSON TICKETS. — So as to prevent tickets being fraudulently withdrawn from the middle of the packets, the Austrian Railways had reels of tickets made in 1910, the strips being perforated between each two tickets, rendering them easily detachable. The earlier reels used to get muddled up, but this was soon remedied. Special racks for ticket reels were also provided, but they were cumbersome.

In spite of this, reels of tickets were suitable for slot machines and supplied to local or suburban booking offices dealing but with a limited number of different kinds of tickets.

Reels of tickets have found a new field in totalising and accounting machines and are frequently used on short lines, such as mountain railways, issuing but a few different tickets.

BIREKA standard machines have from 6 to 9 passages, each of which deals with a reel of one thousand 20 by 47 mm. (25/32" × 1 27/32") tickets having a very special perforation between them(1). The dimensions of the Strasbourg NUMERUS machines differ but slightly from them (2).

There are, on the market, a certain number of other machines whose principles are very similar. The QUICK TILL ROLL TICKET DISTRIBUTOR, manufactured by *Auto Ticket Ltd.* is especially useful for delivering tickets of a single value on lines where a single fare is in force.

Like the *Bireka*, the NATIONAL CASH REGISTER is sometimes used for printing tickets on thin card and registering the sale of each ticket.

For over half a century, British and Overseas omnibus, tramway and motorbus Companies have used tickets which are very similar to the above. They are slightly larger than Edmondson's, their dimensions being 32 by 65 mm. (1 9/16" × 2 9/16"). But since they have been put to multiple uses, some of them have been lengthened so as to accommodate more letter-press and these reach 90, 105, 130 mm. (3 35/64", 4 1/8", 5 1/8") and more.

Owing to the adoption of mechanical ticket machines, soft cardboard tickets are also coming into use on the Continental motorbus and light railway lines (fig. 83). They had previously been used

(1) Their overall dimensions, without till, are :

Number of passages	6	9	6 + 6	9 + 9
Height, cm. (in.) .	39 (15 3/8")	39 (15 3/8")	65 (25 5/8")	65 (25 5/8")
Width, cm. (in.) .	27 (10 5/8")	39.5 (15 9/16")	27 (10 5/8")	39.5 (15 9/16")
Depth, cm. (in.) .	23.3 (9 5/32")	23.5 (9 15/64")	23.3 (9 5/32")	23.3 (9 5/32")
Weight, kgr. (lb.).	9 (19.8)	12.5 (27.5)	16 (35.3)	20.5 (45.2)

Reels are supplied in 160 different combinations of colours.

(2) The dimensions are as under :

Number of passages . .	6	9	9+9	9+9+9	2
Number of tickets per reel	1000	1000	1000	500	1000
Height, cm. (in.) . . .	50 (19 11/16")	50 (19 11/16")	76 (29 7/8")	76 (29 7/8")	30 (11 13/16")
Width, cm. (in.) . . .	25 (9 27/32")	39.5 (15 35/64")	39.5 (15 35/64")	29.5 (11 5/8")	10 (3 15/16")
Depth, cm. (in.) . . .	26.3 (10 23/64")	23.3 (9 5/32")	23.3 (9 5/32")	23.3 (9 5/32")	21 (8 1/4")
Weight without dating appliance, kgr. (lb.) .	12 (26.4)	15.5 (34.2)	24 (52.8)	25 (55.1)	2 (4.4)
Weight with dating appliance, kgr. (lb.) . .	16 (35.3)	21.5 (47.4)	35.5 (76.3)	36 (79.4)	3 (6.6)
Drawer.	with	with	with	without	without

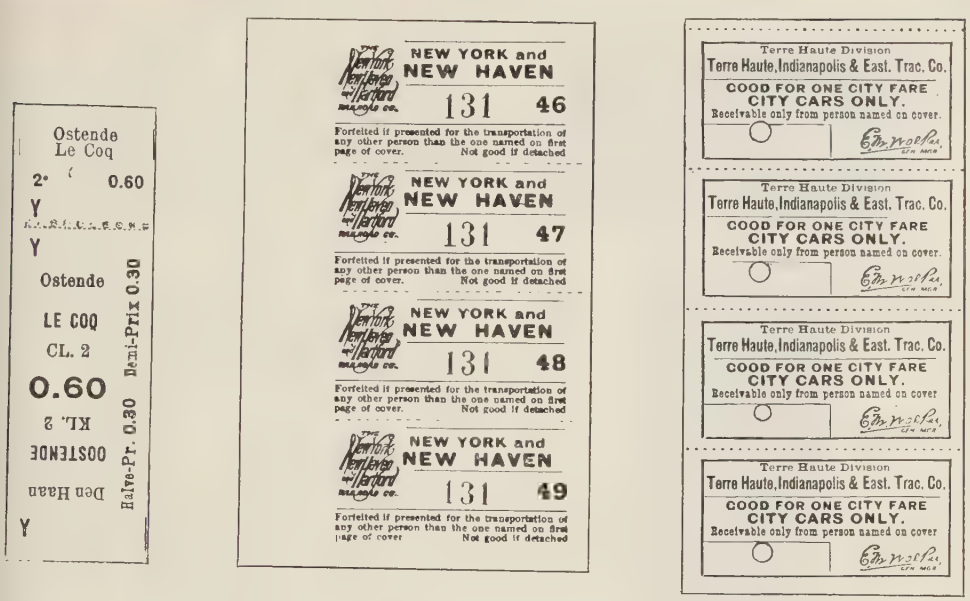


Fig. 84. — Small ticket and stub (Actual size) used since 1885 on the *Belgian National Light Rys. Co.*'s lines worked by the *Brussels-Ixelles-Boendael Narrow Gauge Rys. Co.* These tickets were halved (18 by 22 mm. = 45/64" × 7/8") when delivered to children or military.

Figs. 85 and 86. — Sheets of personal coupons, each valid for one fare — *New York, New Haven and Hartford R. R. Co.* and *Terre Haute, Indianapolis and Eastern Traction Co.* (Red. 3/4).

quite a time, and for the same reason, on Metropolitan and suburban railways.

A number of light railway Companies sell Edmondson tickets at the stations and paper tickets in the cars.

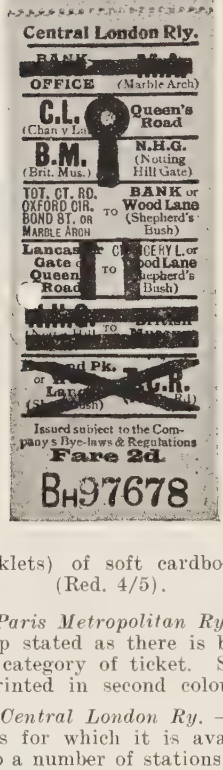
One of them (1) for many years used a system of its own and sold, in the carriages of a large number of lines, thin cardboard tickets between fixed stations. These were originally supplied in packets of 18 × 44 mm. (45/64" × 1 7/8"), but a short perforated stub was soon added to them, which brought their length to 58 mm. (2 9/32") (fig. 84). As the Company used the Belgian system of half-fare tickets, the latter's size was but 18 by 22 mm. (45/64" × 7/8"), surely the smallest tickets ever issued.

Booklets of Edmondson tickets. — When they have a stub, soft cardboard tickets may be bound into booklets. These booklets are sold at a cheaper rate than separate tickets so as to encourage the public to buy them and thus expedite ticketting. They have been much used by underground railways (figs. 87 and 88).

British road transport Companies also issue them to workmen, and for certain categories of return tickets and so on.

Books of coupons are issued between fixed places or at the will of the puchaser. The former, officially called « billets-livrets » (booklet-tickets), which formerly were 77 by 107 mm. (3 1/32" ×

(1) Narrow-gauge *Brussels-Ixelles-Boendael Ry. Co.*


Central London Rly.
BANK
OFFICE (Marble Arch)
C.L. Queen's Road
B.M. (Brit. Mus.) N.H.G. (Notting Hill Gate)
TOT. CT. RD. OXFORD CIR. BOND ST. OR MARBLE ARCH TO BANK or Wood Lane (Shepherd's Bush)
Issued subject to the Company's Bye-laws & Regulations
Fare 2d.
BH97678

Blocks (booklets) of soft cardboard tickets (Red. 4/5).

Fig. 87. — *Paris Metropolitan Ry.* — No value or trip stated as there is but a single price per category of ticket. Safety background printed in second colour.

Fig. 88. — *Central London Ry.* — With list of sections for which it is available, each from or to a number of stations — Characteristic initials and overprinted signs for principal stations.

4 13/64") (fig. 89) (1) have been enlarged in 1936, to 88 by 125 mm. (3 15/32" × 4 29/32"). They comprise, under a stout paper cover, a number of detachable paper coupons, each of which is available on one section or for the entire journey over one of the Companies' lines.

The colour of the coupons is that of the corresponding class. Mixed booklets contain coupons of different classes for different sections. The cover is often in the colour of the two classes (2).

The first sheet has a vertical detachable portion. If this is withdrawn and retained by the issuing agent, the booklet is sold at half price for a child. In some cases, instead of a vertical, an angular detachable portion is substituted at one of the outer corners.

When delivered to passengers travelling in groups, the cover of each booklet bears a red star. Return booklets have a 10-mm. (25/64") wide vertical white band down the cover and, when available for all trains, a vertical 1 mm. (3/64") wide red stripe down the centre. Sunday booklets issued in Germany have a blue instead of a white band. Formerly, both band and stripe used to be wider.

Each booklet bears the words « Anglo-French » or « Italo-Swiss » traffic (or any other, as the case may be) dubbed « contractual traffic », on the cover and the name of each Company on the corresponding coupons.

(1) With the exception of British booklets which were smaller (67 by 104 mm = 2 21/64"×4 5/64") and of Italian, which were larger (90 by 130 mm. = 3 35/64"×5 1/8").

(2) Such as booklets delivered by stations of the *Nord* system to Havre, via *Etat* rail or the *Cie Rouannaise de Navigation*'s boats, the journey from Rouen to Havre taking place, at the traveller's option, in 2nd class by rail or 1st by boat. The corresponding coupon is bicolour, green in the upper half and yellow in the lower. The cover is divided vertically into a yellow portion (to the left) and a green one to the right.

Anglo-French tickets are often of a higher class on the boats than in the trains. Thus, the cover of Paris and London tickets via Dunkirk-Tilbury were brown and green or brown and yellow, as the case may be; division was vertical.

Ce billet est valable par le Chemin de fer South Eastern et Chatham, Charing Cross ou Victoria (West End); ou Cannon Street, St. Paul's ou Holborn Viaduct (Cité), avec faculté de s'arrêter dans les Stations pour lesquelles il y a un Coupon.
LONDRES
à
BRUXELLES,
Par Folkestone-Boulogne ou Douvres-Calais.
PREMIÈRE CLASSE.
NON TRANSFÉRABLE.
Valable pour 7 Jours à partir de la date constatée par le timbre de bureau de depart.
No. 3333
This Ticket is available by the South Eastern and Chatham Railway from Charing Cross or Victoria (West End) Stations or Cannon Street, St. Paul's or Holborn Viaduct (City) Stations, with power to stop at each of the Stations for which there is a Coupon.
LONDON
TO
BRUSSELS,
Via Folkestone-Boulogne or Dover-Calais.
FIRST CLASS.
Fare, £2:9:0
NOT TRANSFERABLE.
For Conditions, see inside.
56 lbs. of Luggage Free.
Available for 7 Days, including the day of issue.
McCorquodale & Co. Limited, "The Armoury," London, S.E.

Fig. 89. — Cover (former size) of international book of coupons — Fixed journey (Red. 3/4) — Issued by the *South Eastern and Chatham Ry.* — Availability, 7 days — Notices concerning stop overs and free carriage of luggage — Dated by perforation.

As it is difficult to print a white band, the coupon is printed leaving a white band in the middle.

Owing to weather conditions, it is less easy to tear out the coupons for the sea passage than the rail ones. It is therefore advisable to render it distinctive either by special printing (fig. 90) or even, as in the *Netherlands Rys.* booklets, by including white signets where needed.

Continental booklets are issued for :

Single or return journeys in each class;
Excursions;
Groups (sociétaires);
Week ends;
Pedestrian tours, etc.

Books of « combined coupons ». — As it is not possible to have booklets of coupons for every conceivable journey, especially when passengers return to the place they started from by roundabout routes, « combinable » coupons for many sections of railways have been prepared and, when bound into books, aggregate an average reduction of 15 %. As with fixed journey booklets, these books may be made up of coupons of various classes and each of them may apply either to a section or to the whole journey over a Company's lines. Their dimensions have been standardised to 100 by 142.5 mm. (3 15/16" × 5 39/64") for the covers, and 100 by 140 mm. (3 15/16" × 5 1/2"), including stub, for the coupons.

When it is necessary to distinguish, among several possible routes, the one the passenger has actually travelled by, the coupon has, either along the right-hand border and along the lower part, a smaller detachable portion (fig. 91). In some cases, these control-portions are

2
2nd Coupon.
No. 54401
Paquebots de l'État Belge.
Pakketbooten van den Belgischen Staat.
Belgian Government Mail Steamers.
BILLET DE SOCIÉTAIRE | GEZELSCHAPSBILJET
London—Ostend
et retour | an terug | and return
3e Classe Rail. via Dover 1re Classe Bateau.
Coupon pour le passage de
Biljet voor de reis van
Coupon for the passage from
DOVER
à | naar | to
OOSTENDE
(Par temps favorable. (Bij gunstig weder.)
(Wind and weather permitting.)
Voyage en groupe d'au moins 15 personnes.
Groepsreis van ten minste 15 personen.
1e Classe. I Klasse.
INCESSIBLE. PERSOONLIJK.
Timbre à date Datumstempel. Date of Issue.

Fig. 90. — Coupon (present size) of international book of coupons available for sea passage — Issued by the *Belgian National Rys. Co.* (Red. 3/4).
Category : group (of at least 15 persons) — Available in different classes : 1st on board and 3rd by rail.
Drawing of a steamer and wavy frame to distinguish coupon for maritime section.

themselves divided into two separable half-portions (1).

Similar divisions of the coupon are sometimes made when, whilst covering the whole trip over a single operating Company, part of it is accomplished by a different means of transportation (2).

Besides the usual items, many coupons bear others concerning stop overs, etc.(3). Other kinds of coupons, without travel validity, concerning customs facilities, tariff reductions or conversely, increase of the rate of exchange, are sometimes inserted. These coupons are further dealt with in PART D.

Cardboard cards. — Their size depends on the amount of printing they are to hold and on control requirements. Certain kinds have been standardised, especially in local traffic; thus German commutation cards are 45 by 70 mm. (1 49/64" × 2 3/4").

When such cards are printed on thin cardboard, they are bound into blocks which are easier to handle (4).

Paper tickets. — Not only tramways and light railways, but main lines use such tickets to a considerable and grow-

(1) The Basle-Cologne coupon used to be available via several of the railways following either bank of the Rhine and also by any of several river steamer services. There was but one control coupon available by all these routes; it was retained by the route that had effectively been followed. (The river services appeared on the back of the coupon.)

(2) The Dover and Brussels coupon is horizontally divided into two sections, the upper available on board ship between Dover and Ostend, the lower, by rail, between Ostend and Brussels. Each one has, at its top right-hand corner, a triangular child's coupon as well.

(3) In Italy, there are spaces prepared for clipping when stopping over. Each of these has a round number of kilometres printed in it.
In Belgium, the Railway Company issues coupons for the Agencies; elsewhere, the latter usually print their own.
In Austria, list of places where stop overs are allowed.
In Hungary, blank coupons with preprinted list of months, of dates and, sometimes, of the hours of the day.
In Austria, blank coupons having an extra counterfoil on the left-hand side as well.

(4) The *Neuchatel Tramways Co.*'s commutation cards have a peculiar shape (rectangle with rounded corners, and an odd shaped stub) ; all round are a series of squares each of which is detachable and is valid for one transportation element. They are nicked off until nothing but the centre portion of the card remains.

Fig. 91. — « Combined coupon » issued by the German *Verein*, with detachable control-portions for optional travel by rail or river (the text for the latter is on the other side of the ticket).

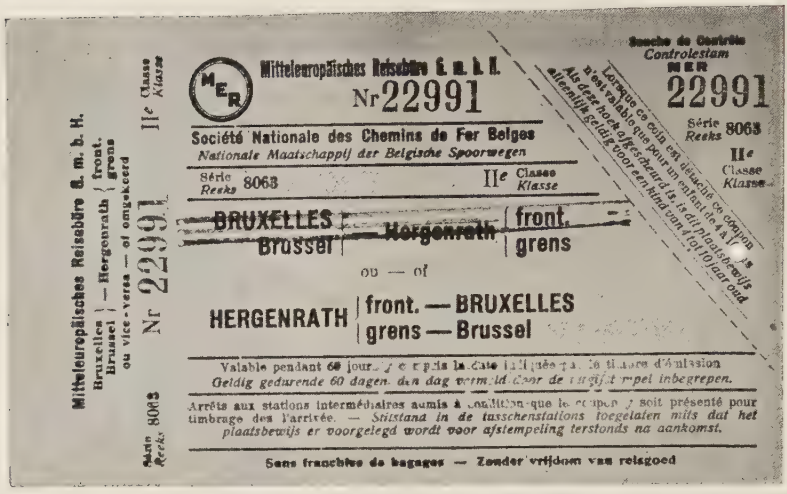
List of stop over stations — Illustration showing whether route implies travelling by rail or by boat (steamer printed at back) — Number of section as given by the *Verein* — Millesime stating what year the ticket was printed — Date of utilisation perforated.

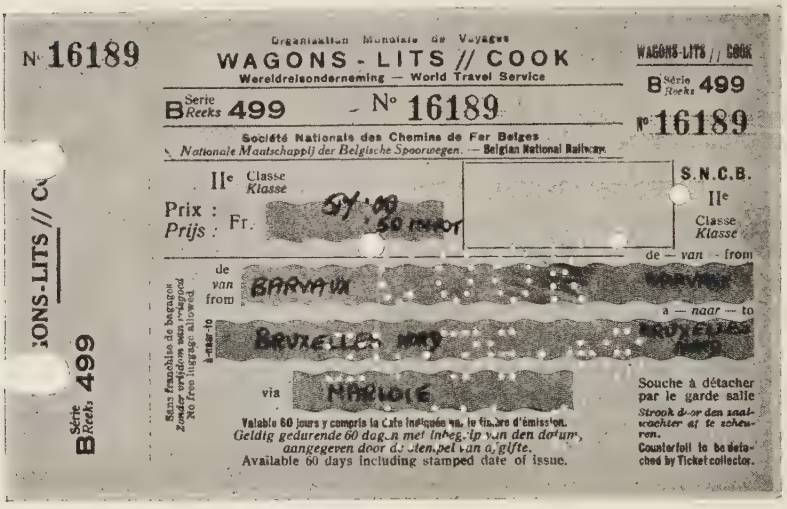
ing extent. They are usually bound in blocks of 50, 100 or 200 of them.

Tramway type paper tickets have long been delivered in light railway trains that stopped at intermediate halts where there was no booking office; passengers then purchased their tickets en route (figs. 94 and 95). Apart from blank tickets or « talons-valeurs » that do not simplify things as much as appears at first sight, the inspector is often provided with a complete set of tickets of every value he may require.

This system of ticketting has reappeared in a number of cases. It is simple when most passengers travel between the same places, as on the Brussels-Antwerp non stop bloc (set) trains when they were first introduced. But when even a single stop was introduced (at Malines), the number of different kinds of tickets, the three classes being taken into account, immediately rose to 20 full-price ones comprising 3 single tickets for each class either way, and as many returns, besides excess tickets for travelling in a higher class.

Since 1936, the *Belgian National Rys. Co.* has turned 96 of its lines into light railways, as far as operation goes and suppressed staff at wayside stations and halts. The guards are provided with a series of tramway type tickets, but though only one kind is stocked, there are separate tickets for each of the prices that may be required between any two stations.


Mitteleuropäisches Reisebüro G. m. b. H.
Bruxelles | — Hergenrath | front.
Brussel | — grens
ou vice-versa — of omgekeerd
IIe Classe Klasse
Nr 22991
Série Reeks 8063
Mitteleuropäisches Reisebüro G. m. b. H.
Nr 22991
Société Nationale des Chemins de Fer Belges
Nationale Maatschappij der Belgische Spoorwegen
Série Reeks 8063
IIe Classe Klasse
BRUXELLES | — Hergenrath | front.
Brussel | — grens
ou — of
HERGENRATH | front. — BRUXELLES
grens — Brussel
Souche de Contrôle
Controlestam
MER
22991
Série Reeks 8063
IIe Classe Klasse
Valable pendant 60 jours y compris la date indiquée au timbre d'émission
Geldig gedurende 60 dagen den dag vermeld door de uitgifte mpel inbegrepen.
Arrêts aux stations intermédiaires admis à condition que le coupon y soit présenté pour timbrage des l'arrivée. — Stilstand in de tusschenstations toegelaten mits dat het plaatsbewijs er voorgelegd wordt voor afstempeling terstonds na aankomst.
Sans franchise de bagages — Zonder vrijdom van reisgoed


Nº 16189
Organisation Mondiale de Voyages
WAGONS-LITS // COOK
Wereldreisonderneming — World Travel Service
WAGONS-LITS // COOK
B Série Reeks 499
Nº 16189
Société Nationale des Chemins de Fer Belges
Nationale Maatschappij der Belgische Spoorwegen. — Belgian National Railway
S.N.C.B.
IIe Classe Klasse
Prix : Fr. 57.00 50 INCL
de — van — from
a — naar — to
via
Souche à détacher par le garde salle
Strook door den zaalwachter af te scheuren.
Counterfoil to be detached by Ticket collector.
Valable 60 jours y compris la date indiquée au timbre d'émission.
Geldig gedurende 60 dagen met inbegrip van den datum aangegeven door de stempel van afgifte.
Available 60 days including stamped date of issue.

« Combinable coupons » (Red. 3/4).

Fig. 92. — Coupon issued by the *Mitteleuropäisches Reisebüro* (Central European Travel Agency) over a foreign line with extremities of fixed journey printed either way — Child, triangular detachable control portion — Availability 60 days; no free luggage — M.E.R. monogram — International number of the section.

Fig. 93. — Blank coupon issued by *Cook/Wagons-Lits* — Extra vertical control-portion (right hand side) which is collected when starting — Validity (date, name of Agency, etc.) by perforation.

Figs. 94 and 95. — Similar paper tickets supplied in 1885 to the *Liége-Maestricht Ry. Co.* and to the *Brussels Tramways Co.* (Red. 3/4).

The dimensions of tramway tickets vary considerably. Many of the early ones were small (figs. 96 to 100) and, on some Systems, no larger than postage stamps (figs. 101 and 102) (1). These paper tickets were printed in sheets and had to be cut out with a pair of scissors! By contrast, recent Berlin tickets are 170 by 45 mm. (6 11/16" × 1 49/64") and American transfers, 230 by 50 mm. (9 1/16" × 1 31/32").

The *Fasbender Printing Works*, of Berlin, have improved the booklets of paper tickets sold instead of commutation cards as shown fig. 103*b* (2); the incision in the edge of each sheet being removed from under the incision of the preceding one, considerably facilitates handling them.

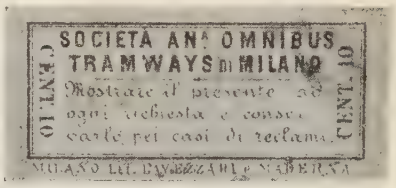
Attention should also be drawn to interperforated strips of tickets which are dealt with hereafter.

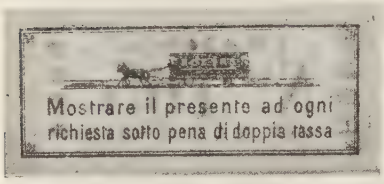
Sheets of paper tickets (fig. 104). — The first Continental tickets were small and grouped in sheets of perforated tickets as are stamps nowadays. These sheets were then bound into blocks. Perforation made it easy to separate one or more tickets at a time. In general use when tramways first started (figs. 105 to 110), in Belgian towns, in Florence, Turin, Barcelona, the Hague and elsewhere, they have been employed in Munich until quite recently.

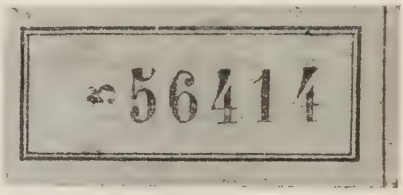
Though these tickets have gone out, the principle remains and has recently been reintroduced on the Belgian railways as elements of mileage booklets, in Italy, to pay fiscal dues and in France,

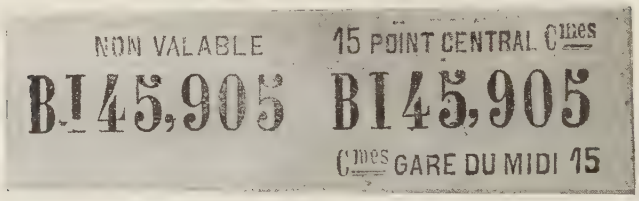
(1) The « grades » of *Bahia* (Bahia cable railways) had tickets 17 by 25 mm. (43/64" × 1") only and the first Lisbon tickets were 22 by 26 mm. (7/8" × 1 1/32").

(2) *Frankfort Tramways.*









Front and back sides of unperforated reel tickets (1865) (Actual size).

Figs. 96-97. — Earliest Rome paper tickets *(Tramway di Roma)* — Notice and illustration at the back — No price stated.

Figs. 98-99. — Earliest Milan paper tickets — Notice and price on the recto — Serial number at the back.

Fig. 100. — Earliest paper tickets having stubs (as large as the ticket itself) — *Belgian Street Rys. and Tramways Co.* (Brussels, 1868).

Old unperforated paper tickets; conductor had to cut them out of the sheets with scissors. (Actual size).

Fig. 101. — Bahia cable railway (about 1865).

Fig. 102. — Earliest Lisbon tickets (same date).

Fig. 103*a*. — Old Italian ticket — Available in 2nd class or, upon payment of a stated extra fare, in first.

Fig. 103*b*. — Sheet of book of reduced-fare paper tickets. (Red. 3/4) — *Munich Tramways* — Map of system — Hour of the day (24 hours) — Date — Number of ticket in booklet (7) — Price overprinted.
These weekly booklets are sold to legitimation card holders.

in coupon-sheets of booklets, for controlling travel over short sections of some of the rail, air or navigation Companies.

Packets of cardboard or paper tickets. — Instead of binding these tickets into blocks, they are sometimes printed in long strips which are folded zigzag fashion along specially prepared perforations. This is done for extra fares paid on *Swiss Federal Rys. trains* (paper tickets) and for all forms of road transport as well (soft cardboard tickets).

Paper bands. — In the States, Canada, and Mexico, multiline tickets are not issued in booklets as with us, but are made up of long strips or bands, 72 to 75 mm. (2 53/64" × 2 61/64") wide, whose length varies with the journey. Similar bands are even used for mileage tickets and folded zigzag into cardboard covers. Sections are collected en route, which finally only leaves the upper portion in the passenger's hands. They have no stub as we know it : the lower portion is really the stub and is kept by the booking clerk.

The length of these tickets is occasionally considerable; we have some, 7 feet in length, and it appears tickets up to 10 feet long have actually been issued. The European system of booklets seems much preferable, easier to check, and facilitates control.

Other shapes or arrangements of rectangular tickets. — Instead of grouping successive coupons in booklets as with us, or one above the other, as in America, they are sometimes laterally juxtaposed in the East, as for Sino-Japanese interline tickets, printed on stout paper or even on thick card as shown in figure 111.

The Seaboard Air Line Ry. (U.S.A.) uses, for certain transfer coupons, a curious type of control envelope.

Square metal tokens are to be found on the *Watson Bay Ferry Co.* (1) (fig. 116) and elsewhere, but other shapes have rightly been preferred.

The corners of all types of commutation tickets and passes are frequently rounded off so as to be able to slip them

(1) These are square aluminium tokens 25 by 25 mm. (1" × 1").

Fig. 104. — Complete sheet of the first tickets of the *Brussels Tramways Co.* (Red. 3/4).

easily into one's pocket (fig. 113), and the same idea has been applied to metal tokens on the *Calais Tramways* (fig. 115) (1) and elsewhere.

Triangular tickets. — So as to punch duplex tickets, they should previously be folded along a dotted line; the two de tachable portions can thus be punched a the same time before tearing off the part that is to be handed to the passenger. When these tickets are folded along a diagonal, each portion is of triangular shape. The *Mommens Printing Works* of Brussels, first introduced such tickets (fig. 117) which were used on a number of light-railway lines (2).

Certain *New South Wales Govt. Rys* single or double commutation cards are truncated triangles (fig. 118).

Polygonal tickets. — The only hexagonal tickets we know of are the *Paris-Orléans* Edmondson platform tickets (fig. 121). The sides have indentations for use in slot machines. Similar identations are to be found on other tickets.

OCTAGONAL CARDBOARD TICKETS. — These are mostly used for season tickets. They are to be found in France for slightly en larged Edmondson platform tickets (3) for larger cards in England (4), in Au stralia (fig. 119) (5) in New Zealand (6) and elsewhere. Certain old Belgian pas ses were octagonal (7) (fig. 114), whic

(1) These are in white metal, with a hole in the centre; their main dimensions are 26 by 26 mm. (1 1/32" × 1 1/32").

(2) *Belgian National Light Railways Co.; Liége Est-Ouest Tramways.*

(3) French *Nord.* — Since 1937, the slot machines have been adapted to use rectangular tickets instead.

(4) Thick season ticket cards of the *L.N.E. Ry.;* well engraved cards of the *Great Western Ry.*

(5) *New South Wales Govt Rys.*

(6) *New Zealand Govt. Rys.*

(7) Passes issued from 1866 to 1875 by the *Société Générale d'Exploitation des Chemins de fer.*

Figs. 105 to 110. — Reproduction in actual size, of the earliest (paper) tickets of various towns.

Antwerp Maritime Tramways Co. (1879).
Antwerp Tramways Co. (1873).
Louvain Tramways, with odd value (1875).
Ixelles and Etterbeek Tramways, Brussels (1873).
Luxemburg Tramways.
Frankfort Tramways, with corner control portion.

hape is still retained in France (figs. 122 nd 123) (1).

Octagonal metal tokens. — Several ompanies struck veritable metal tickets. he oldest of them only have the Compay's name and a serial number.

This shape is often found in metal toens or coins. In many cases, round okens are avoided; on the other hand, square coins are too angular. This has been mitigated by cutting off the corners, which turns them into octagons, regular or irregular according to the quantity that has been lopped off (fig. 124). These coins were made when bullion was scarce, and all mentioned that they were only available for the purchase of tickets until a given date (2).

(1) *Nord, Est* and *P.O.-Midi.*

(2) The *Tramways et Omnibus de Lyon* (Lyons Tramways and Omnibuses) have struck brass octagonal tokens, 21 by 21 mm. (53/64" × 53/64"), good for a 25-centime trip and valid until 31 Dec. 1927.

The *T.C.R.P.* of Paris had different shaped aluminium tokens. The bus ones, which showed a motorbus end view, were 25 mm. (1") in diameter and were good for a 35 centimes worth ride until Dec. 31, 1931; the tramway 21-mm. (53/64") tokens, were good for a 25-centime ride until the same date.

Regular octagonal tokens of 20 mm. (25/32"), had been used previously and were good for a 20 centimes worth ride until 31 Dec. 1923 *(fig. 258)*.

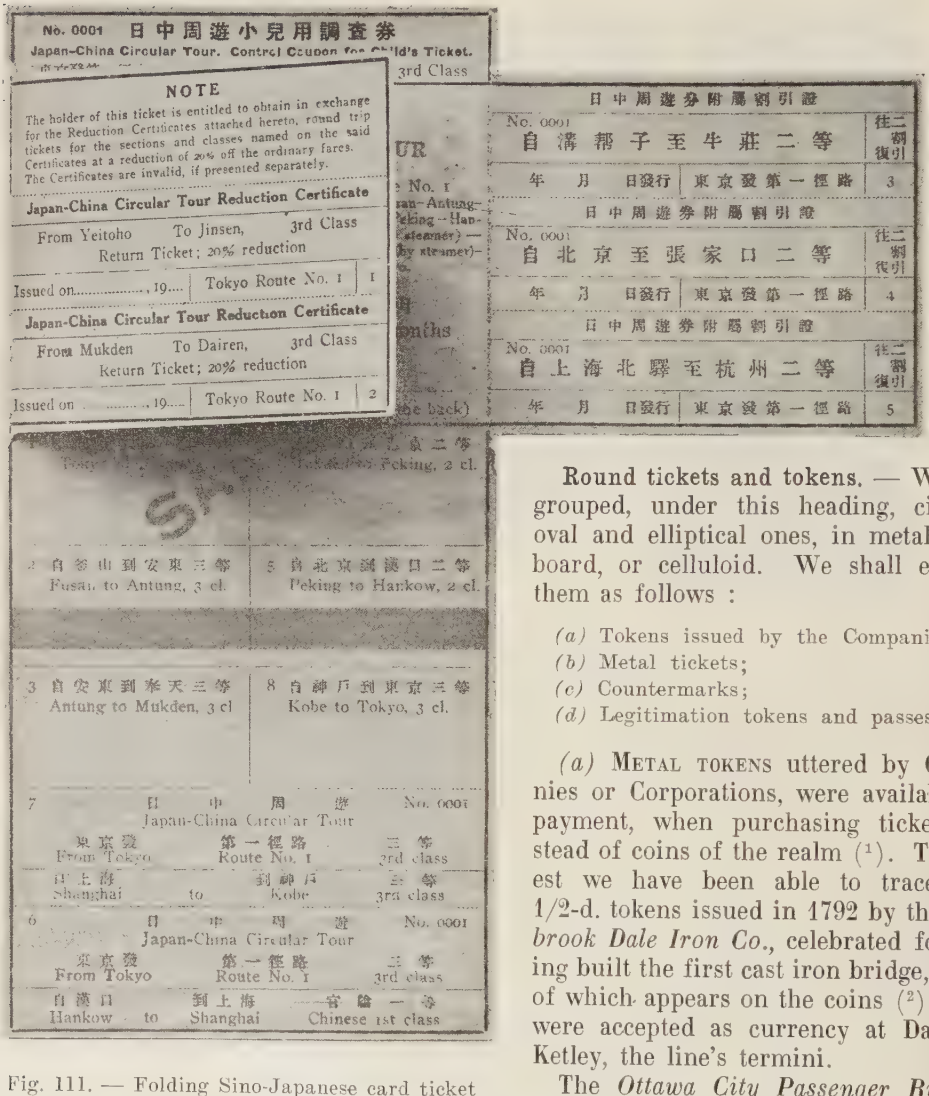

No. 0001 日中周遊小兒用調查券
Japan-China Circular Tour. Control Coupon for Child's Ticket.
3rd Class
NOTE
The holder of this ticket is entitled to obtain in exchange for the Reduction Certificates attached hereto, round trip tickets for the sections and classes named on the said Certificates at a reduction of 20% off the ordinary fares.
The Certificates are invalid, if presented separately.
Japan-China Circular Tour Reduction Certificate
From Yeitoho To Jinsen, 3rd Class
Return Ticket; 20% reduction
Issued on....., 19.... | Tokyo Route No. 1 | 1
Japan-China Circular Tour Reduction Certificate
From Mukden To Dairen, 3rd Class
Return Ticket; 20% reduction
Issued on....., 19.... | Tokyo Route No. 1 | 2
日中周遊券附屬割引證
No. 0001
自 溝 幫 子 至 牛 莊 二 等
往二割復引
年 月 日發行 | 東京發第一經路 | 3
日中周遊券附屬割引證
No. 0001
自 北 京 至 張 家 口 二 等
往二割復引
年 月 日發行 | 東京發第一經路 | 4
日中周遊券附屬割引證
No. 0001
自 上 海 北 驛 至 杭 州 二 等
往二割復引
年 月 日發行 | 東京發第一經路 | 5
Peking, 2 cl.
2 自 釜 山 到 安 東 三 等
Fusan to Antung, 3 cl.
5 自 北 京 到 漢 口 二 等
Peking to Hankow, 2 cl.
3 自 安 東 到 奉 天 三 等
Antung to Mukden, 3 cl
8 自 神 戶 到 東 京 三 等
Kobe to Tokyo, 3 cl.
7 日 中 周 遊 No. 0001
Japan-China Circular Tour
東京發 第一經路 三 等
From Tokyo Route No. 1 3rd class
自上海 到神戶 三 等
Shanghai to Kobe 3rd class
6 日 中 周 遊 No. 0001
Japan-China Circular Tour
東京發 第一經路 三 等
From Tokyo Route No. 1 3rd class
自漢口 到上海 一等
Hankow to Shanghai Chinese 1st class

Fig. 111. — Folding Sino-Japanese card ticket issued by the *Japanese Government Rys.* (Red. 3/4). — It includes detachable coupons entitling holder to 20 per cent reduction on other lines.

Round tickets and tokens. — We have grouped, under this heading, circular, oval and elliptical ones, in metal, cardboard, or celluloid. We shall examine them as follows :

(a) Tokens issued by the Companies;
(b) Metal tickets;
(c) Countermarks;
(d) Legitimation tokens and passes.

(a) METAL TOKENS uttered by Companies or Corporations, were available for payment, when purchasing tickets, instead of coins of the realm [1]. The oldest we have been able to trace were 1/2-d. tokens issued in 1792 by the *Coalbrook Dale Iron Co.*, celebrated for having built the first cast iron bridge, a view of which appears on the coins [2]. These were accepted as currency at Dale and Ketley, the line's termini.

The *Ottawa City Passenger Ry. Co'* tokens (fig. 126) were good for one fare. They were made of brass and were of 25 mm. (1") diameter.

(1) In a booklet entitled « Railway Medals and Tokens », published by *The Railway Club* in 1901, and which Messrs. Spink and Son, Ltd., of 5, King St., St. James's, London, were good enough to lend us, the author, Mr. G. W. J. Potter quotes a few examples.

(2) This bridge, built by Darby over the Severn at Coalbrook Dale in 1779, was 100 feet long and 55 feet above water level.
The Ketley incline, shown on the reverse, was constructed in 1789.

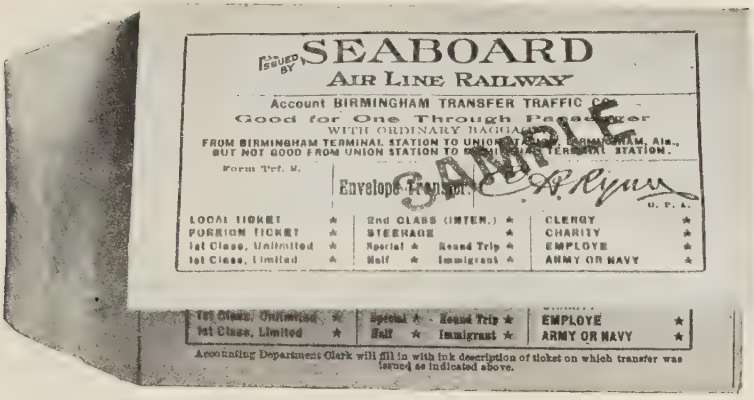
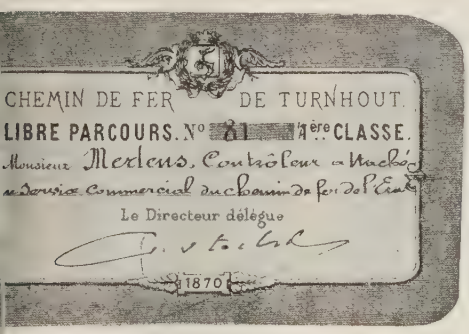


Fig. 112. — *Seaboard Air Line* (U.S.A.) control envelope-ticket — With category parameter — The exchange ticket is placed in the envelope portion which is sent to the Auditor. (Red. 3/4).


CHEMIN DE FER DE TURNHOUT.
LIBRE PARCOURS. N° 81 1ère CLASSE.
Monsieur Mertens, Contrôleur à Malines
au Service Commercial du Chemin de fer de l'Etat
Le Directeur délégué
1870

SOCIÉTÉ GÉNÉRALE
D'EXPLOITATION DE CHEMINS DE FER
N° 669 LIBRE PARCOURS 1ère Cl.
sur tout le réseau
M. Mertens, Contrôleur à l'administr.
des Chemins de fer de l'Etat
1870

non-rectangular cardboard passes (1870).

113. — *Turnhout Ry*, with rounded corners.

114. — *Société Générale d'Exploitation de Chemins de fer*, polygonal card.

White metal tokens of various denominations. (Actual size).

Fig. 115. — *Calais Tramways* — Square with rounded corners.

Fig. 116. — *Watson Bay S. S. and Ferry Co. Ltd.* — Square token.

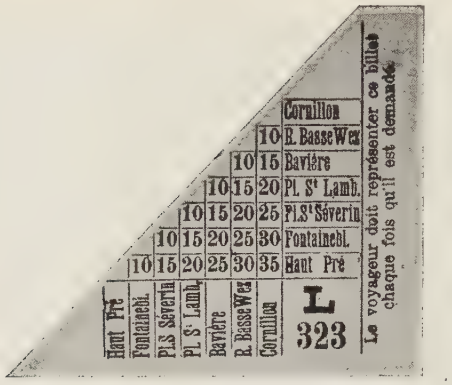


Fig. 117. — Duplex triangular paper ticket (1881). — *Liége Est-Ouest Tramways Co.* (Red. 3/4).

(b) TICKETS. — Whereas the earliest metal ticket was octagonal, its successors were usually circular. Thus the *Gloucester and Cheltenham Ry.*, a company which was incorporated as early as 1809 had round bronze coins. The name of the class in which they were available, appeared on them (1), as also on the *Montreal and Lachine R. R. Co.*'s (fig. 128) in Canada (2). These early coins were real works of art.

Upon its inauguration in 1834, the *Dublin and Kingstown Ry.*, the first railway in Eire, used silver-nickel tickets (3), and

Various shapes of *New South Wales Govt. Rys.* monthly commutation cards. (Red. 3/4).

Fig. 118. — Truncated card — Child, half-price.

Fig. 119. — Octagonal card — Lady.

Fig. 120. — Oval card — Apprentice.

The number of the month, the year and, where necessary, the route, is overprinted.

Colour designs help to differentiate the cards.

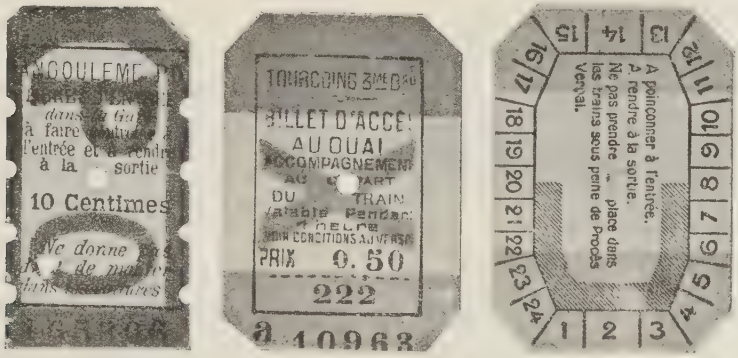
Further tokens of the kind have been issued down to our own times, but celluloid has, in most cases, been substituted for metal.

the *Costa Rica Ry.* did the same until 1905 (fig. 127). But they all had a considerable drawback : none of them stated what trip they had been issued for.

(1) Diameter, 49 mm. (1 15/16").

(2) Diameter, 38 mm. (1 1/2").

(3) These coins, 20 mm. (25/32") in diameter, showed a locomotive on the obverse and an inscription (Second-class ticket) on the reverse.



Platform polygonal tickets. (Red. 4/5).

Fig. 121. — Hexagonal ticket, *Paris and Orléans Ry.* — Frame and Company's initials in red overprint.

Figs. 122-123. — Recto and verso of French *Nord* octagonal platform tickets (obsolete since a few months — List of all the hours of the day, at the back, those between 8 p.m. and 8 a.m. being shaded.

(c) Countermarks. — This is really the oldest of all kinds of tickets as it was used in the Greek and Roman baths and theatres (1). The ticket which had been bought at the booking office or elsewhere was collected on entering the station and a countermark given to the passenger instead. He retained the latter until it was collected in turn either on the train or at the exit. His countermark was then sent back where it came from so as to be used again, and so on indefinitely.

Countermarks differed according to

(1) The following information on the subject has been kindly supplied by the *Bell Punch Co.*, of London.

Patrons of old Greece theatres used to buy tokens at the entrance. They were of bronze, or zinc or of terracotta, and showed a lion or a goddess such as Athena (the Romans' Minerva) on the obverse, and on the reverse, letters on figures indicating the category and number of seat that was to be occupied.

These tokens, the « tessaræ » of the Romans, were also made of ivory or bone, porcelain or stone and used by them, in the theatres, the circuses and the thermæ. They were collected by employees and returned to the offices for future use.

Bronze tokens were still used by subscribers to XVIth Century theatrical performances. Towards the close of the following century, general tickets which betokened free entrance to all seats, were of silver and cost £ 150 per annum in the Royal Theatres. Apart from them, ordinary metal countermarks remained in use until towards 1890. But as advance bookings increased, some other system had to be devised; countermarks were then superseded by paper tickets.

Curiously enough, they were to reappear in the cinemas which were being started and which gave non-stop shows, thereby precluding the possibility of advance bookings which had caused theatres to abandon countermarks. The cinemas had both metal and bone countermarks, but as it was impossible to check them properly, reels of tickets were soon used instead.

Reproduction, in actual size, of metal tokens.

Fig. 124. — Polygonal tokens of the *Lyons Omnibuses and Tramways.*

Fig. 125. — Round tokens of the *T.C.R.P.*, Paris — Stating date until which they are valid — Good for a 35-centime fare.

Fig. 126. — *Ottawa City* round tokens, good for one fare; they bear no indication of value.

class and journey. But this system which, is not a safe one, has gradually been abandoned everywhere, or very nearly so, with the exception of navigation services.

The *London and Greenwich Ry.*'s countermarks (1837) were of bronze (fig. 130) or silver bronze and, later, of cardboard (1); the *Sheffield and Rotherham Ry.*'s checks were of bronze only (2).

Metal tickets (in actual size).

Fig. 127. — *Costa Rica Ry.*

Fig. 128. — *Montreal and Lachine R.*

(d) SEASONS AND PASSES. — This last group comprises coins that serve both for legitimation purposes and as passes.

Formerly, they used to be given to the Company's Directors and others and often showed artistic views of the Railway's works of art, such as the viaduct

(1) There exist two types of copper coins, 32 and 22 mm. (1 1/4" and 7/8") in diameter respectively, each with the same design on both sides; the one showed a galloping winged horse, the other, the Company's coat of arms. This railway was inaugurated in three sections, on February 8, 1836, December 14, 1836, and December 24, 1838. Its whole 3 3/4 miles are on viaducts which explains why it cost £ 733 333. The normal British rule is for trains to keep to the left and not (as in Germany) to the right. For many years (from 1850 to 1901) the London and Greenwich Railway provided an exception, as trains kept to the right.

(2) This 5-mile railway was inaugurated on the 31 Oct., 1838, and absorbed by the *Midland* on the 21 July, 1845. The coins bore a figure (such as « No. 3 ») besides their serial number.

Old *London and Greenwich Ry.* coins. (Actual size).

Figs. 129-131. — Obverse and reverse of director's free ticket.

Fig. 130. — Passenger's countermark — With Company's coat of arms — The two sides are identical.

London and South Western Ry. season tickets. (Actual size).

Figs. 132 and 133*a*. — Front view of 1st and 3rd-class seasons.

Fig. 133*b*. — Back view of both the above, showing Company's name and stating the cases are the property of the Company.

which carried the *London and Greenwich Ry.* across London (1) (figs. 129 and 131). The Spanish *Norte*'s passes were of ivory (fig. 40).

Circular cardboard tickets have hardly been used outside the British Isles where they have served both for season tickets and passes. They were slipped into annular cases which belonged to the Company (2) and were entrusted to the hold-

(1) These bronze medals were 38 mm. (1 1/2") in diameter.

(2) Each of these card bearing cases is serially numbered. It states : « This case is the property of the Company », and bears the General Manager's name.

Figs. 134 to 136. — Legitimation tokens granting free travel when on duty — *Bradford City Tramways* — Both types, one of which has the City's coat of arms and the other a heraldic emblem, have the same text on the reverse (fig. 135). (Actual size).

Round tokens of modified shape. (Actual size).
Fig. 137. — *Marseilles Tramways.*
Figs. 138 and 139. — *Oslo* Transport.
Fig. 140. — *Washington Ry. and Electric Co.*

er for a limited period at the expiration of which they were to be returned to the Railway Company (figs. 132 and 133). A sheet of mica or of some such substance preserved the actual cardboard ticket on either side. The inner diameter of the annular ring was 28 mm. (1 1/8"), the outer, 38 mm. (1 1/2"). It bore the

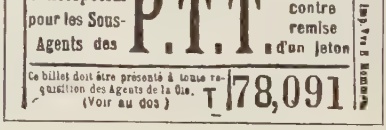

Cie des Tramways de Nice et Littoral
Billet spécial pour les Sous-Agents des
P.T.T
A délivrer contre remise d'un jeton
Ce billet doit être présenté à toute réquisition des Agents de la Cie. (Voir au dos)
T 78,091

Fig. 141. — Special paper ticket delivered in exchange of post, telegraph or telephone employee's tokens. (Red. 3/4) — *Tramways de Nice et du Littoral* (Nice and Seaside Tramways).

Company's name in gilt letters enamelled on a dark blue, a red or a white background (1).

Medals are still used for legitimation purposes; they are entrusted to the bear-

(1) Most such cases had carbine hooks so as to attach them to watch chains.

r when on duty, for one or several jour-eys which he may accomplish without ayment (figs. 134 to 136) (1).

The following table gives the weight of several of the coins and tokens we have quoted :

COMPANY.	Date.	Metal.	Weight, troy ounces.	Size, Inches.
Coalbrook Dale	1792	Copper.	0.45	1 3/16"
Gloucester-Cheltenham. . . .	...	Bronze.	0.8	1 5/8"
Dublin-Kingston.	1834	Nickel-plated silver.	0.15	7/8"
London-Greenwich, coat of arms.	1837	Copper.	0.35	1 1/16"
Id. winged horse.	1837	Do.	0.14	1 1/4"
Sheffield-Rotherham	1838	Do.	0.25	1 1/16"
Surrey Side Street Ry. . . .	1861	Brass.	0.1	15/16"

Modified round tickets. — So as to ender forgery more difficult, other sha-es have been resorted to.

Marseilles had aluminium tokens with avy edges (fig. 137) (2) but it is more sual to produce coins with a hole in the iddle, after the fashion set by Belgium or its cheaper coins many years ago. hey are to be found in *Montreal*, in *yons*, in *Calais*, in *London* (3) and else-here and on the Istambul *Metropolitan* hich used two types of countermarks fig. 39), the first in brass (diameter, 0 mm. i. e. 25/32") for ordinary pas-engers, the second in zinc (thin sheet, 5 mm. i. e. 1 3/8" in diameter), for of-cials and commutation ticket holders (fig. 138). Inscriptions on both of them were in French and Turkish.

Oslo again has two types of different sizes, both with S-shape holes (4) (figs. 138 and 139); the *Washington Ry. and Electric Co.*'s have W-shaped holes (fig. 140).

As these tokens are sold in rolls under face value, tickets bought with them cannot be accounted for on the same basis as others purchased with money. Special tickets or transfers are therefore issued in exchange for them (fig. 141).

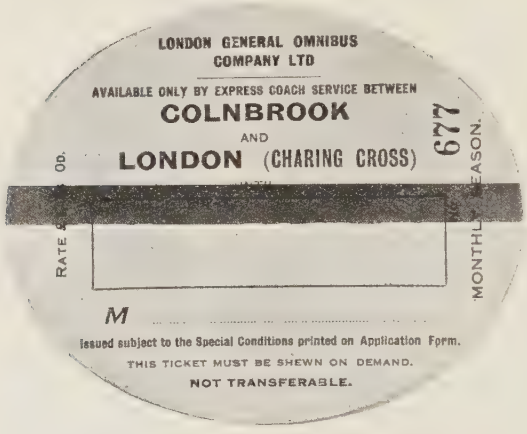
Oval or elliptical tickets. — These are usually made of cardboard; metal ones, though sometimes to be met with, are exceptional.

(1) The *Bradford Corporation* entrusted these medals to nurses. Diameter, 30 mm. (1 3/16").

(2) These tokens, 25 mm. (1") in diameter, were good for a 15-centime trip. The obverse had the City's coat of arms.

(3) Old *L. C. C. Tramways.*

(4) The 1926 brass tokens were 17 mm. (43/64") in diameter; the aluminium ones, 19 mm. (3/4"). Designs on both sides were identical.



Oval cards. (Red. 3/4).

Fig. 142. — Pass-out check — *Liége and Maestricht Ry.* (1880) — Delivered in light trains.

Fig. 143. — Reduced price card — *Bordeaux Electric Tramways and Omnibus Co.*

Fig. 144. — Monthly season ticket. — *London General Omnibus Co. Ltd.* — Available by express coach service.

They are issued as pass-out checks (1) (fig. 142) or as travel tokens (2) and more often still as free tickets which are collected at the end of the journey (3).

(1) On the former *Liége and Maestricht Ry.*, now incorporated in the *Belgian National Rys.*' system; axes : 71 and 44 mm. (2 51/64" and 1 3/").

(2) *Bordeaux Electric Tramways,* for octroi and municipal service staff; axes : 66 and 42 mm. (2 19/32" and 1 21/32").

(3) *Les Messageries Nationales,* Paris; axes : 72 and 49 mm. (2 53/64" and 1 15/16"); *Tramway Spécial du Jardin d'Acclimatation,* Paris; axes : 59 and 38 mm. (2 21/64" and 1 1/2").

ormerly, also as « personal seals » (1) ranted to various people, such as large tock or share subscribers or landowners who had ceded the Company with little r no compensation what it needed for its ight of way.

They are only used, nowadays, for sea- on tickets (fig. 144) (2).

The functions of oval metal tokens are dentical with other shaped ones. One of ne earliest London Tramways, one mile

ig. 145. — *Sheffield and Heeley Omnibus* (1852) elliptical ticket. (Actual size) — 3-d denomination.

ong, inaugurated from Marble Arch to otting Hill on the 23 March, 1861 (3),

Elliptical silver free passes used in 1870. (Actual size).

Fig. 146. — *S. P. and D. Ry. Co.* (British India).

Fig. 147. — *Great Indian Peninsula Ry.*

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(1) The *Compagnie Générale des Omnibus*, Paris, used them when it started; axes 58 and 36 mm. (2 9/32" and 1 7/16").

(2) The axes of the *London General Omnibus Co.*'s were 93 and 75 mm. (3 21/32" and 2 61/64").

Les Tramways mécaniques des Environs de Paris used them to a considerable extent, for workmen's weekly tickets. These cards, 112 mm. (4 13/32") horizontally by 75 mm. (2 61/64") vertically, bore the names of each day of the week.

The *Nord Ry.* also had oval commutation cards, which it used for 2nd-class passengers, the first being octogonal and the third, rectangular. Their largest dimensions were 112 and 82 mm. (4 13/32" and 3 15/64").

(3) The rails having been laid at a higher level than the road surface, accidents caused by this obstruction were frequent and the line was dismantled before the end of the same year.

The oval coins had 21 and 16 mm. (13/16" and 5/8") axes.

The *Surrey Side Street Ry. Co. Ltd*, which inaugurated shortly after same its line from Westminster Bridge to Kennington, showed a two-horse tram car with the words « Train's Patent » on the obverse and had ist name on the reverse.

used them; others are to be found in Sheffield (fig. 145) (1). The former were of brass, the latter of bronze.

They were also used as nominative free passes in various countries; bronze, silver, and gold ones were to be found in India. Fig. 147 shows an old *G. I. P.* pass (2) and figure 146 a curiously shaped pass of the *S. P. and D. Ry. Co.*, issued in 1870 (3).

(To be continued.)

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(1) John Shortridge's *Sheffield and Heeley Omnibus* issued what were actually bronze 3-d. tickets in 1852; their dimensions were 27 by 17 mm. (1 1/16" and 11/16").

(2) Dimensions of axes 29 and 23 mm. (1 3/16" and 29/32").

(3) Dimensions of axes 28 and 20 mm. (1 7/64" and 25/32"). The model of an anchor joins the annular portions of the pass.

[625. 253]

Air brake accelerators. Single accelerators and coupled accelerators,

by Dr. Ernst MÖLLER, V. D. I.

(From *Glasers Annalen.*)

Accelerators are apparatus used in railway braking in order to increase the speed of transmission of the braking action along the train.

When compressed air is exhausted from the brake pipe which is continuous throughout the train, either from the driver's brake valve on the locomotive, or, in case of an emergency application or break-away, from any other point on the train, then the brakes are applied on each single vehicle; the air stored in the auxiliary reservoirs on the vehicles flows through the triple valves to the brake cylinders.

The rate at which the compressed air in the brake pipe expands is highest at the exhaust opening; at that point the pressure drops almost immediately to nil. The greater the distance from the exhaust opening, however, the lower the rate of the pressure reduction which commences after the arrival of the initial « head surge », because the reduction in pressure, together with internal and external friction, slow down the rate of exhaust. The deep wave of air pressure reduction originating at the exhaust opening, flattens out with extreme rapidity as the distance increases. It follows that any given pressure reduction together with the resulting braking action are propagated through a train with a proportionate continuous reduction in speed.

It is true that the initial « head surge » is propagated through the brake pipe at the speed of sound in the atmosphere, i.e. 330 m. (1 083 ft.) per sec. The force of this surge is not, however, sufficient to operate the triple valve pistons and slide valves and to start the brake application. For reasons arising from the brake operation it is necessary for the triple valves to have a certain inertia so that they will only respond after a sufficient difference in pressure has been created on both sides of the triple valve piston, the head of which is subject to the brake pipe pressure while the rear face is subject to the pressure in the auxiliary reservoir previously charged from the brake pipe.

The speed at which the braking action is transmitted through a train is called the speed of propagation. It is obtained by dividing the length of a given train by the time which elapses from placing the handle of the driver's brake valve into the emergency position to the moment the brakes apply on the last vehicle.

The speed of propagation of the first air brakes manufactured about 1870 was approximately 140 m. (459 ft.) per sec. for a brake pipe length of 290 m. (951 ft.); on a train four times as long it dropped, for the above mentioned reasons, to approximately 75 m. (246 ft.) per sec.

The loss in application time and particularly the reactions(shocks, and break-aways, due to the period of time which elapsed between the application of the brakes on the first and on the last vehicles, called for a higher speed of propagation. It was possible to obtain a more uniform braking by considerably reducing the rate of the rise in brake force, but this was done at the cost of much longer times of application.

The first step to increase the speed of

propagation was the invention of the quick-acting triple valve by Westinghouse, in 1887. This triple valve was the ordinary apparatus used for charging the auxiliary reservoir and for filling and exhausting the brake cylinders, but when an emergency application took place it tapped in addition air directly from the brake pipe in order to cause an additional drop in brake pipe pressure on arrival of the « head surge » and thus to reinforce the operating surge. As this action took place on every vehicle, the speed of propagation was thus not only independent of the length of the train, but was, moreover, considerably increased. The more suddenly the air was tapped, the higher the rise of the « head surge » and the greater the speed of propagation.

Originally, the large tap of air necessary for emergency applications was carried out by means of the usual triple valve, the air from the brake pipe being admitted to the brake cylinders and taken advantage of to increase the speed of the brake force rise. With the small pressure reductions corresponding to service applications, the triple valve piston and slide valve moved over into a medium position, the service position, limited by means of a stop such as a spring, and only when a sharp pressure reduction took place did they move past this limit into the emergency position and withdraw a considerable volume of air from the brake pipe. As, however, the same piston controlled both the service and the emergency application, it often happened that this piston moved over from the service position into the undesired emergency position, as the friction of piston and slide valve are not constant but vary within certain limits. It was therefore considered advisable to separate completely the parts used for service applications from those used for emergency application.

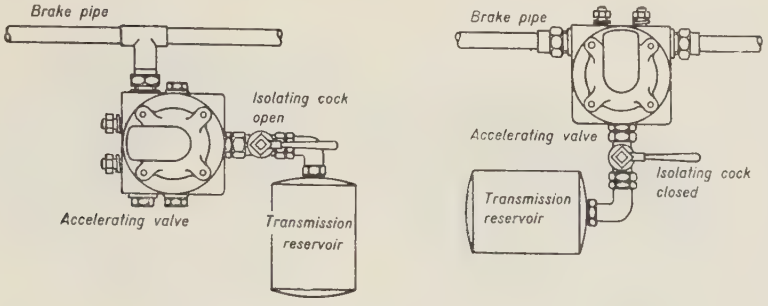
Special valves, called « accelerators », were therefore designed to increase the speed of propagation of the emergency applications. They were mounted separately in the brake pipe and exhausted the brake pipe air rapidly to atmosphere at the moment an emergency application took place. Later, the brake pipe air was also admitted into special chambers, called transmission chambers, the volume of which was proportionate to that of the air pipe of the vehicle, so that the brake pipe was only exhausted down to a « pressure of equilibrium ».

This system of renewing the brake surge from vehicle to vehicle has remained the basis for accelerating the braking action. In the end, service applications were also accelerated in this manner; only small transmission chambers could be used in this case because of the smaller reduction in pressure required whereas large chambers were permissible in the case of emergency applications as they are already caused by a larger reduction in brake pipe pressure.

In the course of time the speed of propagation of emergency applications was increased up to 200 m. (656 ft.) per sec and the lower speed corresponding to service applications was made independent of the length of the train by means of chambers of a smaller size.

The « accelerators » have also been continuously developed. By careful examination of all facts concerned it has recently been possible to increase the speed of propagation up to 300 m. (98 ft.) per sec. and it has even been possible to obtain a speed of propagation of approximately 1 400 m. (4 590 ft.) per sec i. e. a multiple of the theoretical limit value of 330 m. (1 083 ft.) per sec. by an ingenious combination of two accelerators.

Below we give a description of the two most recent accelerators of the Knorr Bremse A. G., the « single accelerator » and the « coupled accelerator ».



(*a*) connected to the brake pipe. (*b*) mounted in the brake pipe.

Fig. 1. — Single accelerator.

The single accelerator.

The body of the single accelerator is a small cast iron cube. It is either mounted in (fig. 1*b*) or connected to (fig 1*a*) the brake pipe. Two stud bolts are used to fix the accelerator on the vehicle. The transmission reservoir is a special reservoir connected to the valve. By means of an isolating cock, located between both, the accelerator may be cut out of service.

Figure 2 shows sections of the Knorr single accelerator and indicates at the same time its mode of operation. Air from the brake pipe flows through the nozzle 1 of the spring-loaded operating piston into the control chamber. When a slow reduction of the brake pipe pressure takes place during a service application, the control chamber merely exhausts slowly into the brake pipe. If, however, a sudden reduction of the brake

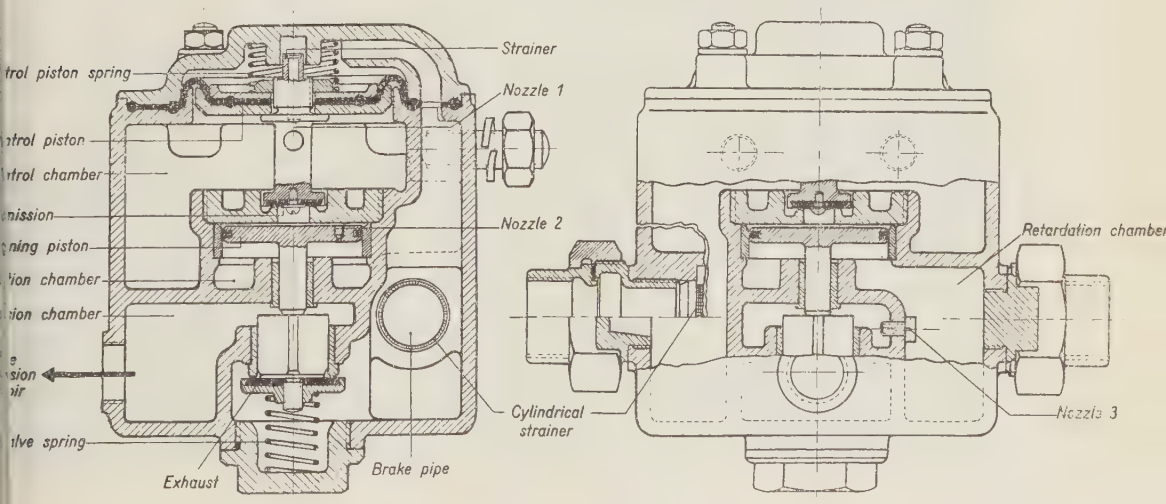


Fig. 2. — Section of a single accelerator.

pipe pressure takes place, then the control chamber pressure forces the piston upwards, as it cannot exhaust quickly enough through the « sensitivity port » 1; compressed air from the control chamber is then able to flow through the admission valve and is admitted to the opening piston which is forced down, opening the large exhaust of the brake pipe. Compressed air from the brake pipe is thus suddenly admitted through the transmission chamber and the isolating cock into the transmission reservoir, the volume of which is proportionate to that of the brake pipe on the vehicle. This creates a sudden considerable drop in brake pipe pressure.

Below the opening piston is a small retardation chamber which is slowly filled through nozzle 2 and prevents the exhaust valve from « fluttering » under the rapid pressure variations, so that the exhaust remains fully open until the pressures in the brake pipe and in the transmission reservoir have equalised.

After a short period the pressure in the control chamber will have equalised through nozzle 1 with that in the brake pipe, then the control piston spring will close the admission valve. Similarly when the pressures on both sides of the opening piston will have equalised through nozzle 2 the exhaust valve spring will close the large exhaust. The air above and below this piston escapes through nozzles 2 and 3 into the transmission reservoir, which is itself vented to atmosphere through a port in the isolating cock.

The component parts of the valve are of suitable design. The air is filtered through both a cylindrical and an ordinary strainer before it reaches sensitivity port 1. Instead of the former piston with ring, subject to continuous variations of friction and tightness caused by lubrication and temperature which affected the reliability, a rolling diaphragm of constant sensitivity and great tightness is used. An admission valve, which has the advantage of a more uniform adhesion compared with the variable friction of a slide valve, and which in addition opens a large section of admission for only a small piston travel, i. e. for a small pressure reduction in the control chamber, replaces the use of a slide valve, although this is quite reliable for the simultaneous control of several ports. On account of the great excess of pressure available and of its short time of operation, it has been possible to use only a ring to seal the opening piston, the clearance volume of which has been kept very small. Its dimensions have been proportioned relatively to the volume of the control chamber and to the size of the admission valve in such a way that it opens rapidly a passage of maximum size from the brake pipe to the transmission reservoir with a minimum stroke.

The transmission chamber located between the exhaust valve and the isolating cock is sufficiently small to avoid that the accelerator alone propagates a pressure reduction along the train when the transmission reservoir is cut out of service. Thus the accelerating feature can be cut out of service in the simplest possible manner. The vent hole in the cock is so arranged that after closing the cock the accelerator is completely shut off from the atmosphere, so that even with a faulty accelerator it is impossible for any brake pipe air to escape.

By arranging the isolating cock behind the accelerator it is possible to mount this valve in the immediate vicinity of the brake pipe (figs. 3 and 3*a*); this arrangement is important for a high speed of propagation as the surge is obliged to cover the distance from the brake pipe to the accelerator twice.

The speeds of propagation up to 300 m. (984 ft.) per sec. attainable with these single accelerators are satisfactory for trains of medium length fitted with brakes having a slow pressure rise in the brake cylinders. This particular point

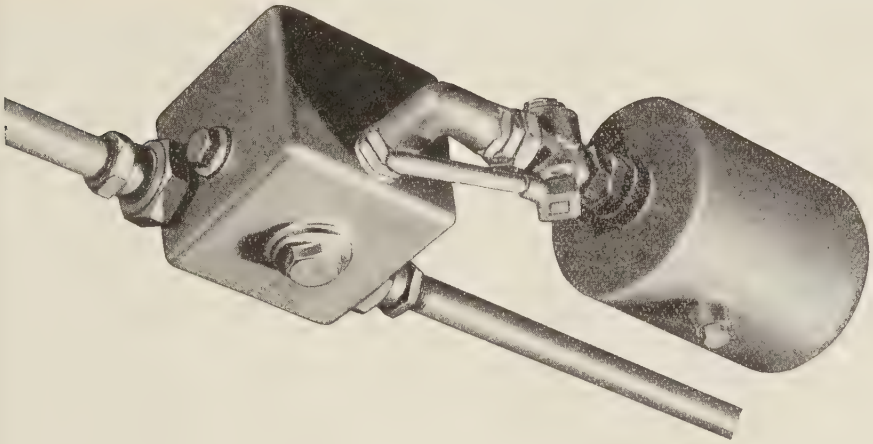


Fig. 3. — Single accelerator mounted in the brake pipe.

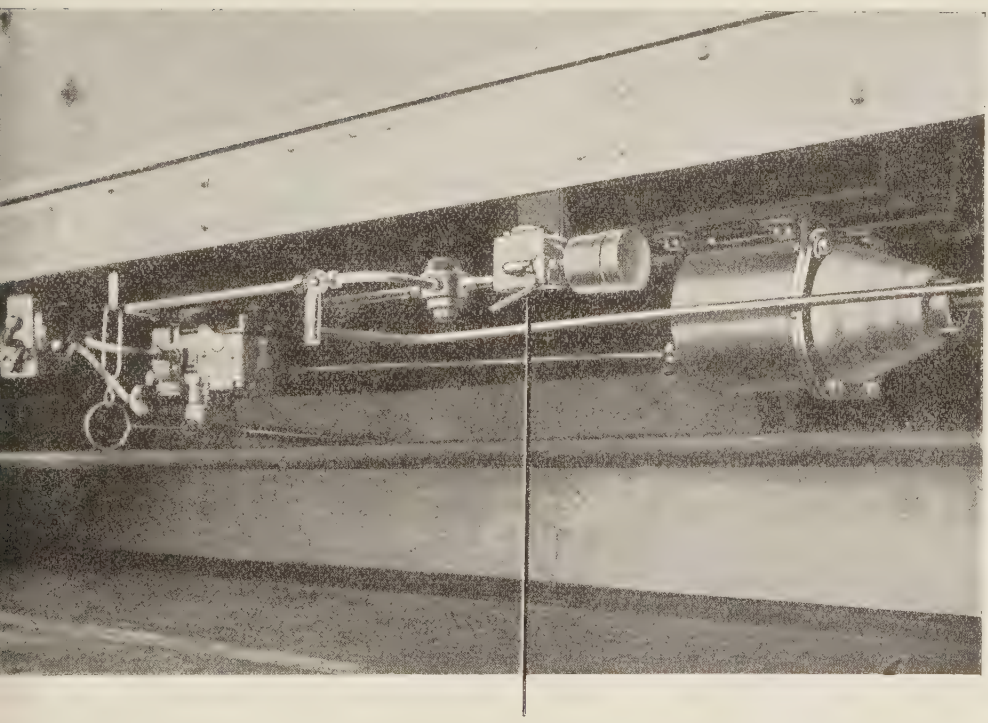


Fig. 3*a*. — Single accelerator in Hildebrand-Knorr brake equipment.

will be shortly examined at the end of the present article.

Coupled accelerators.

In order to reduce the braking distances of high-speed trains it became necessary to increase the speed of propagation to a still higher value than that obtainable by means of the single emergency accelerators, as it appeared particularly desirable to avoid any loss in braking distance caused by delayed application of the brakes at high speeds. In order to obtain short braking distances a rapid rise of the brake pressure build-up on each vehicle is necessary, which also calls for a high speed of propagation, as otherwise when making emergency applications at low speeds, shocks and reactions occur on the train, as the coefficient of friction between brake block and wheel varies with the speed.

It was therefore necessary to design an apparatus which would still further increase the speed of propagation. In order to attain this object, a single accelerator was divided into two portions; at the head of the vehicle was fixed the portion comprising the spring-loaded control piston and its nozzle, the control chamber, the admission valve, and the opening piston, whilst at the rear was mounted the portion comprising the exhaust valve and transmission chamber or a special reservoir. The opening piston was connected by means of a steel wire to the exhaust at the rear of the vehicle and a tractive effort of this piston was obtained by admitting the air pressure to its opposite face.

Figure 4 shows a simplified diagram of the single accelerator and figure 5 shows how it has been divided into two valves 1 and 2 and how they are connected by a coupling wire, which has given this arrangement the designation « coupled accelerator ».

When charged, the brake pipe and the control chamber of the coupled accelerator are both at the same pressure. If a rapid exhaust of air from the brake pipe causes a strong depression at valve 1, then the pressure in the control chamber forces the main piston upwards, as in the single accelerator, and opens the admission valve. Air from the control chamber is thus admitted to the traction piston which opens the exhaust in valve 2 by a pull on the wire and admits air from the brake pipe into the empty transmission chamber. A secondary depression wave is thus created at the rear of the vehicle, immediately ahead of the rear brake coupling, a long time before the first wave, which has caused the pull on the connecting wire, ever reaches the rear end of the vehicle.

The opening jerk is transmitted in the steel wire as an elastic wave having a speed of approximately 5 000 m. (16 400 ft.) per sec. In this manner the speed of propagation is considerably increased on a vehicle; in the brake couplings, i. e. between the vehicles, the speed remains the same as before. The mean speed of propagation resulting from these two speeds of propagation varies, of course, with the length of the vehicle.

During practical tests the following speeds of propagation, taking into ac-

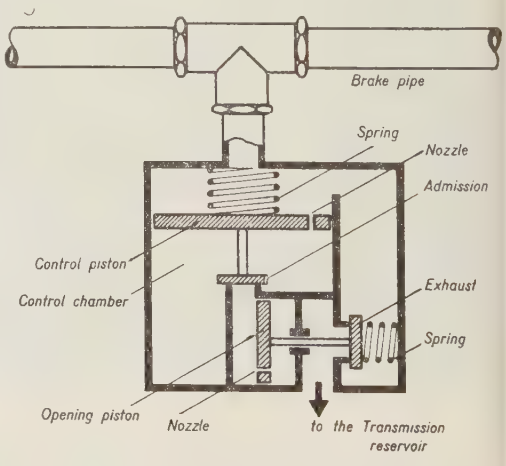


Fig. 4. — Diagram of the single accelerator.

count the valve application time lag, were recorded :

1 100 - 1 200 m. (3 610 to 3 940 ft.) per sec. on 20 m. (65.6 ft.) long vehicles,

1 000 m. (3 280 ft.) per sec. on 15 m. (49.2 ft.) long vehicles,

800 m. (2 620 ft.) per sec. on 10 m. (32.8 ft.) long vehicles.

If it is possible to mount all the valves immediately in the rear of the coupling cocks, speeds of 1 400 m. (4 590 ft.) per sec. are obtained on 20 m. (65.6 ft.) long vehicles.

For such speeds the method previously described for measuring the speed of propagation was too inaccurate. Irregularities in the operation of the driver's brake valve may result in errors of 30 % or more. The speeds of propagation were therefore measured by recording the moment when the air is admitted to the first and last transmission chamber. This method of measuring is permissible when ascertaining the operating results of the accelerator because the high speed of propagation and the possibilities arising therefrom do not apply to the short locomotive brake pipe, but to the far longer pipe of the complete train.

As soon as the pressures in brake pipe and control chamber equalise, following the operation of the valve, i.e. a coupled acceleration, the admission in valve 1 is closed and the pressure in front of the traction piston drops, the compressed air escaping through the port in the traction piston. The pressure of the transmission chamber of valve 2 acting upon the return piston closes the exhaust assisted by the exhaust valve spring, and simultaneously pulls the traction piston back to its normal position. After the exhaust has been closed the return piston rises off its stop in order to avoid unnecessary loading of the valve during the next stroke.

With the mode of operation of the coupled accelerator as shown in figure 5, acceleration is possible in one direction only, namely from left to right. In service it must be possible to accelerate in both directions. Each end of the vehicle therefore carries a valve body comprising an admission part (valve 1) and an exhaust part (valve 2) which are connected by two separate coupling wires with the corresponding parts in the valve body at the other end of the vehicle (fig. 6).

The operations described in reference to figure 5 are now possible in both directions. Both accelerators, however, apply in every case. For instance, should the surge arrive from the left, then the drop in pressure arising on the right also opens the exhaust in the left-hand part by means of the right-hand admission parts. This action from rear to front, however, is without influence upon the speed of propagation.

As with the single accelerator, all parts are the result of careful tests and design. In connection with the tests and trials of the Grunewald Test Department for Brakes, of the Deutsche Reichsbahn, due consideration has been given to the service requirements. As on the single accelerator, a cut-off valve is provided to cut the coupled accelerator out of service, by closing the transmission chamber. In addition a finger connected to the traction piston is arranged to project through the body for easy indication of whether the exhaust ports are closed or not. The projection of the finger would also indicate any broken wire. Pipes are provided for the protection and guidance of the coupling wires which are not drawn tight, but are completely loose so that deformations of the vehicle underframe or temperature variations do not affect them. It was possible to run the wires free from any tension because of the elastic transmission of the sudden pull. Figure 7 shows a coupled accelerator type E mounted on the headstock of a corridor carriage in a transverse pipe connecting both brake couplings. Immediately connected to the accelerators are coupling boxes shown in figure 8, which

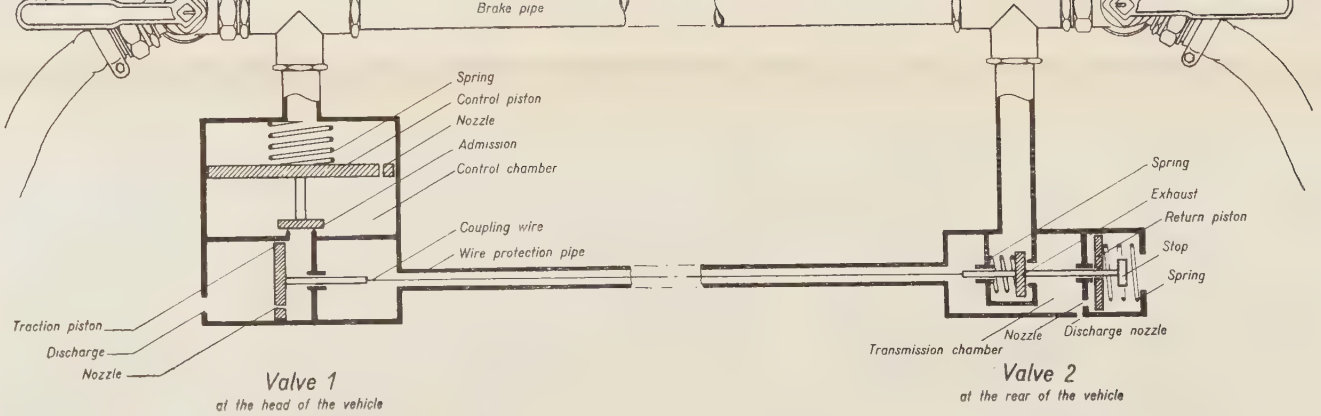
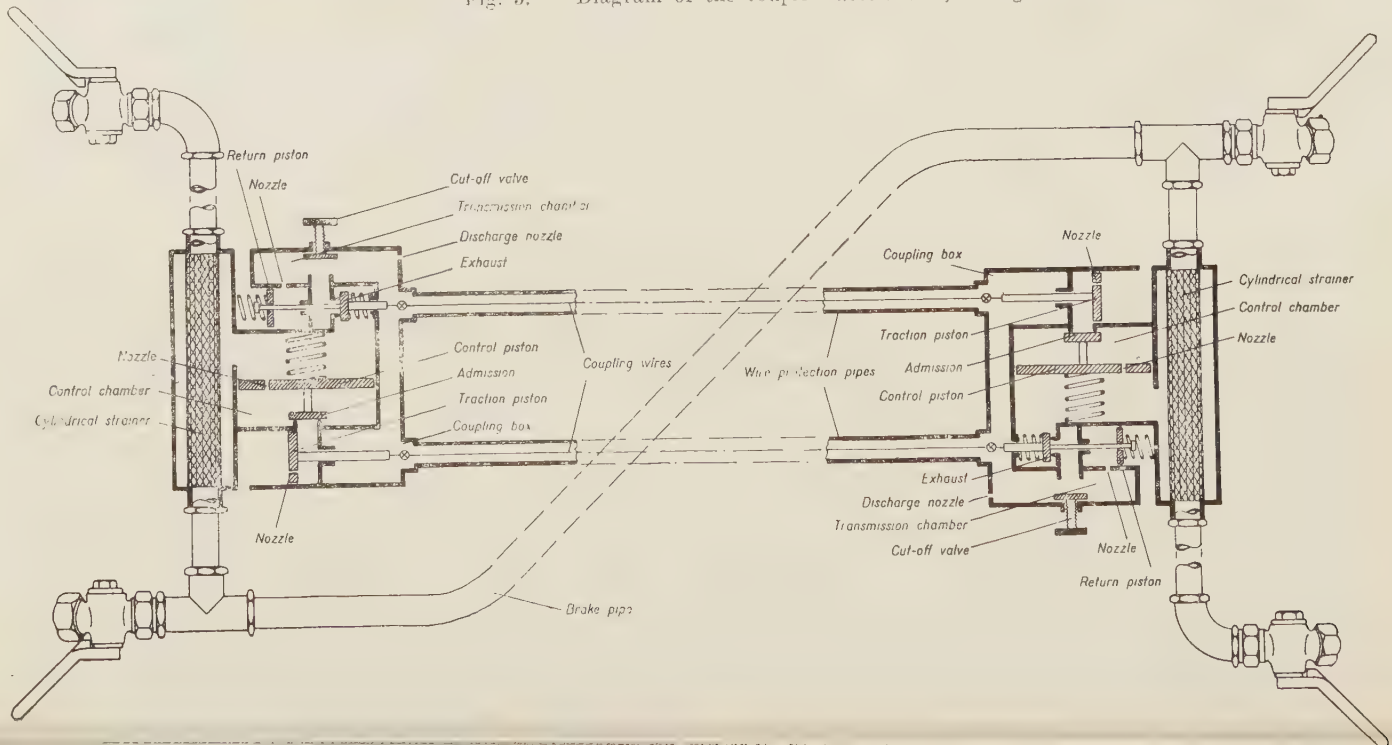


Fig. 5. — Diagram of the coupled accelerator, acting in one direction only →.



are used, on the one hand to facilitate the mounting of the accelerators, and, on the other hand, to protect the threaded wire connections. The coupling boxes, together with the wire protection pipes, make up the transmission chambers.

After long and exhaustive tests the Deutsche Reichsbahn have fitted about 350 corridor carriages supplied in 1935 with coupled accelerators in order to test their reliability on a large scale. The provision of coupled accelerators is contemplated as an addition to the Hildebrand-Knorr brake for high-speed trains (Hik ss).

There are several reasons why a further increase of the speed of propagation obtained in this way may be considered unnecessary. The problem of immediate electric operation in particular, which is only possible for continuously attended constant train units as used in fast urban traffic, need not be considered for main line service; this problem should therefore be dropped not only because of the unreliability of the additional electric couplings required between vehicles and because of the necessity to have special electric relay valves alongside the pneumatically operated triple valves, but, above all, because the continuous electric operation would have to be introduced in all European countries having an international carriage circulation. With regard to this particular point the coupled accelerators do not affect the international agreements on couplings in any way; they have been so dimensioned that their action is propagated even over several vehicles without coupled accelerators.

No definite rules can be laid down regarding the decision when accelerators should be considered necessary, whether single accelerators would meet the case or whether coupled accelerators are called for. This decision depends mainly on the length of the train, the highest running speed, the time of brake pressure build-up, the value of the braking ratio,

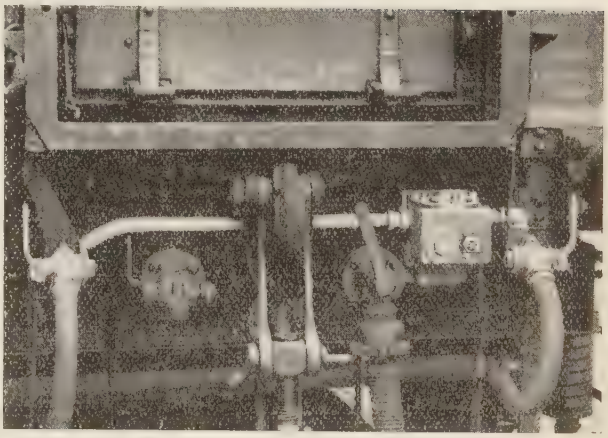


Fig. 7. — Coupled accelerator type E mounted on the headstock of a corridor carriage.

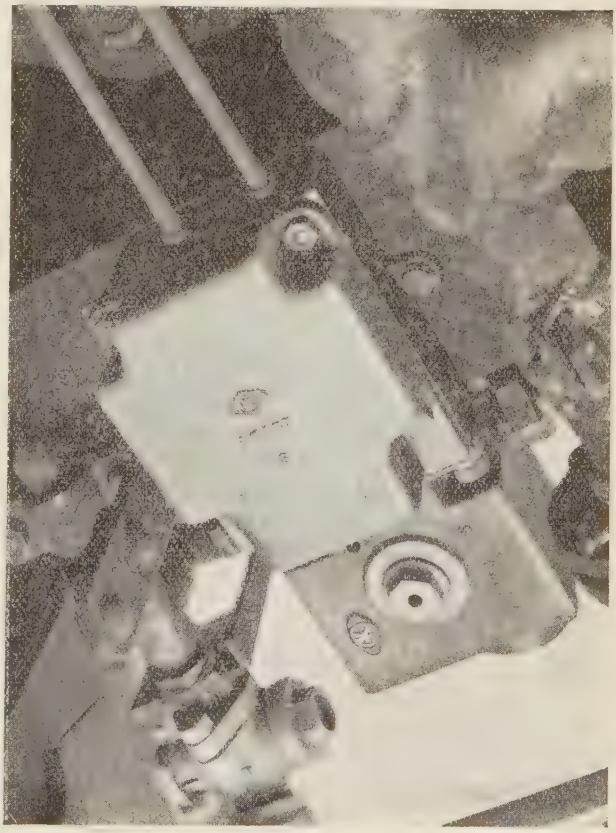


Fig. 8. — Bottom aspect of the coupling box and the wire protection pipes.

the permissible stop distance, and the buffer type in service, and in most cases will have to be decided after running tests carried out by the railway administration concerned.

Very short trains having their vehicles rigidly coupled together or fitted with shock absorbing buffers will not require accelerators even with high speeds and short times of brake pressure build-up.

Accelerators may also possibly be unnecessary for passenger trains of medium length, i.e. comprising up to 60 axles and fitted with shock absorbing buffers, because of the existing low rate of brake pressure build-up and of the low speeds at which they are running for the present.

Accelerators were also not required until now for the longest goods trains as their rate of brake pressure build-up is held as low as from 30 to 60 seconds and their speeds remain at a low level.

On express trains, however, with their high running speeds and their short period of 5 seconds for brake pressure build-up, accelerators have been used for a fairly long time in order to reduce the braking distance and to steady the train while applying the brakes.

Coupled accelerators will be introduced in regular service for the first time on vehicles to be included in the future longer express trains running at speeds exceeding 120 km. (75 miles) an hour and requiring a rate of brake pressure build-up of only 2 seconds.

The range of use of accelerators depends therefore on the future development of rail transport. The accelerator problem will become still more important when higher average speeds will be called for, when longer trains will have to be run at shorter intervals in order to meet the rising traffic demands or when military considerations require rapid mass transportation. Under such circumstances it might even become possible that fast goods trains of medium length, having a rapid rate of brake pressure build-up will be provided with single or even coupled accelerators. There can be no doubt that the actual trend of the general development is mainly to raise both the speed and the density of the traffic circulation by making better use of the existing lines and by increasing the length of trains.

* * *

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[625. 113]

The plotting of curved track by means of the measurement of the versines,

by Dr.-Ing. Gerhard SCHRAMM, Reichsbahnrat, Berlin.

SUMMARY.

1. The different methods of surveying curved track.
2. Methods by calculation.
   (a) General remarks.
   (b) Calculation with the use of trigonometrical tables.
   (c) Calculation without the use of trigonometrical tables.
3. Graphical method.
4. Comparison and accuracy of the methods.

* * *

1. — The different methods of plotting curved track.

As is known, the plan of a curve starting from the measured versines can be plotted on paper. For example, M. CHAPPELLET has put forward a method by calculation, in this *Review* (1). But this problem can also be solved in various other ways, in particular graphically by means of the *angles diagram,* a solution often adopted by those who know this method, but about which little has up to now been published. This is a deficiency which we propose to remedy by the present article, in which we shall describe the methods by calculation as well as the graphical method, giving three solutions by calculation which differ partly from the CHAPPELLET method.

For the *graphical* method it is not necessary to use trigonometrical functions; the solution *by calculation* can be obtained as desired with or without these functions. We give examples of both methods, so that the practical application will not cause any difficulty to the reader.

Although to-day, by reason of the increasing use of the *angles diagram* (Nalenz-Hofer method) it is less often necessary than formerly to prepare plans for realignment schemes and for the pegging out of curves, there are always a number of cases where it is not possible to dispense with a site plan. It is notably desirable to make use of large-scale detail plans for the graphical examination of connections in curves, and in such cases the preparation of plans with the help of versine measurements offers great advantages.

Up to the present, when it was required to prepare a site plan, the general procedure was as follows : First of all a polygonal base was set out and the lengths of the sides were measured, and also the angles with a theodolite. Then intermediate points were ranged as necessary by means of ranging rods between the corners of the polygon, from which points offsets to the track in question were measured. These measurements were plotted on the plan to the desired scale. This procedure is long and complicated. On the other hand, by proceeding directly with the measurement of the versines of the curve with a view to setting it out by the angles diagram method, it is possible to dispense

(1) *Bulletin of the Railway Congress*, June 1936. p. 598.

with the setting out of a special polygonal base and the measurement of angles, because the measurement of the versines constitutes a quite sufficient basis for a plan of the curve in question. In fact, one can always measure the versines and chords from 20 to 30 m. (about 70 to 100 ft.) long much more rapidly than one can set out a polygonal base with intermediate points and measure the angles with a theodolite.

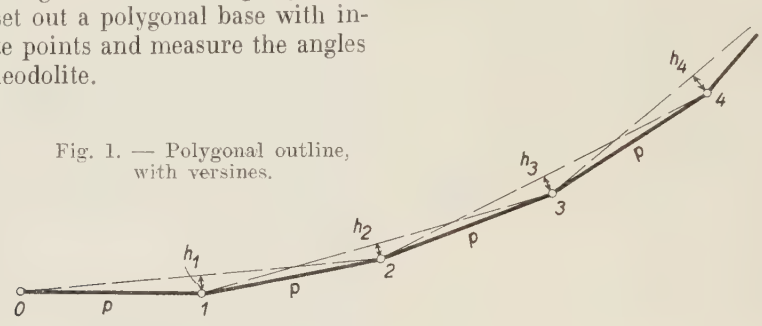


Fig. 1. — Polygonal outline, with versines.

2. — Methods by calculation.

(a) General remarks.

If on the inside of a rail on a curve points are marked at equal distances *(p)*, the whole of these points constitutes a *polygonal* outline all the sides of which have the same length p (fig. 1). We will give the vertices of the polygon the consecutive numbers 0, 1, 2... and measure the versines corresponding to three vertices, calling them h_1, h_2, h_3...

The polygonal outline is clearly determined by the sides p and the versines h. To plot it on a plan, one might first of all propose to join by a purely graphical method the sides p and the versines h to the desired scale, in the following manner : Draw the first side 0-1 of the polygon (fig. 2). About point 1 describe a circle of radius h, which cuts the semi-circumference of a circle of diameter 0-1 at point M. Produce the straight line 0-M for a length equal to itself, which gives the following vertex 2 of the polygon. The following vertex, 3, is obtained in the same way with the side 1-2 and the versine h_2, and so successively all the angles and sides of the polygonal outline.

While theoretically correct, this proce-

dure is practically useless for the following reasons :

The versines h are generally so small that they cannot be reproduced on plans of the usual scale (1 : 1000, 1 : 500 or 1 : 250). Point M is, therefore, only ob-

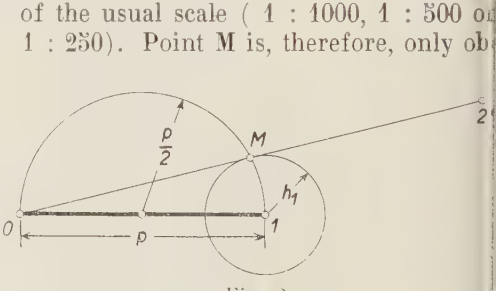


Fig. 2.

tained in an inaccurate manner. The production of the line 0-M as far as point 2 has the effect of doubling this error and as we proceed to the following points the errors in the location of the vertices of the polygon are increased according to the laws of calculation of errors, in such a way that the plan becomes more and more inaccurate as the plotting pro-

ceeds. Consequently this method is useless in practice.

In order to obtain a sufficiently accurate plan it is necessary rather to calculate, by means of the lengths of the sides p and the versines h, the *abscissæ* and the *ordinates* of the vertices of the polygon, plotted on the first side 0-1, which is taken as the axis of the abscissæ (method by calculation), or else determine graphically the distances e of the vertices of the polygon from an imaginary arc of circle (graphical method). We will first of all examine the methods by calculation.

Let us suppose we are looking for the abscissæ x (fig. 3) and the perpendicul-

The *abscissæ* x of the versines are obtained by a successive summation of the different sections of abscissae Δx :

$$x_k = \sum_1^k \Delta x \quad . \quad . \quad . \quad (3)$$

The *difference of the ordinates* between two adjoining vertices *k-1* and k is :

$$\Delta z_k = p \cdot \sin \varphi_{k-1} \quad . \quad . \quad (4)$$

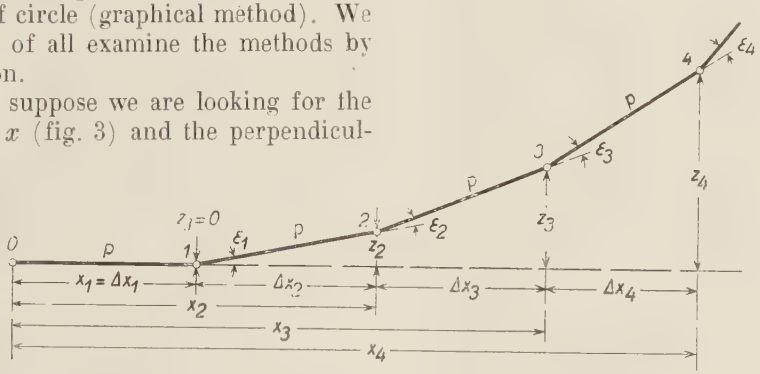


Fig. 3. — Abscissæ and ordinates of a polygonal outline.

ır ordinates z of the vertices of the polygon, plotted from the produced straight ine 0-1 which is taken as the axis of the ıbscissæ with origin 0. We will call the ıngles of the polygon ε_1. ε_2, ε_3... and the ıngles of inclination of the sides of the ›olygon to the abscissæ φ_1, φ_2, φ_3 ... For a given point k of the polygon the ıngle of inclination $k/k+1$ of the foll›wing side is, therefore :

$$\varphi_k = \sum_1^k \varepsilon \quad . \quad . \quad . \quad . \quad (1)$$

Figure 4 shows a detail of figure 3. The *difference of the abscissæ* between two adjoining vertices *k*-1 and k is :

$$\Delta x_k = p \cdot \cos \varphi_{k-1} \quad . \quad . \quad (2)$$

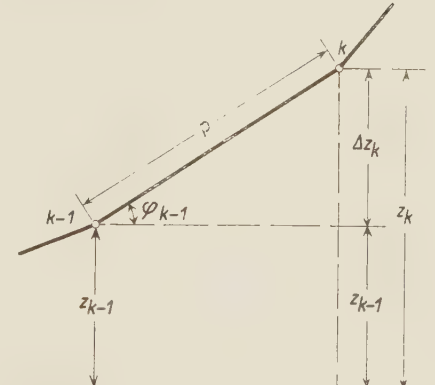


Fig. 4. — Enlarged detail of figure 3.

The ordinates z of the vertices of the polygon are obtained by a successive summation of the different sections of ordinates Δz :

$$z_k = \sum_1^k \Delta z \quad . \quad . \quad . \quad (5)$$

There remains now to express in these equations (2) and (4) the angles φ by the measured versines h. In figure 5 the

Fig. 5. — Versines and angles of the polygon.

two angles α at the base of the isoceles triangle 0-1-2 are sufficiently exact for all practical cases :

$$\alpha \text{ (expressed in radians)} = \frac{h}{p} \quad . \quad . \quad (6)$$

As a matter of fact, the versines h are always very small in relation to the sides p of the polygon, so that one can assume that $\sin \alpha = \alpha$. The angle of the polygon, which is the exterior angle of this triangle, is

$$\varepsilon = 2 \cdot \alpha$$

At any point k of the polygon, the angle of the polygon is, therefore :

$$\varepsilon_k = \frac{2}{p} \cdot h_k \quad . \quad . \quad . \quad (7)$$

Consequently, the angle φ_k (in radians) is, according to equation (1) :

$$\varphi_k = \sum_1^k \frac{2}{p} h = \frac{2}{p} \sum_1^k h \quad . \quad (8)$$

or, measured in degrees :

$$\varphi_k{}^0 = \frac{180}{\pi} \cdot \frac{2}{p} \cdot \sum_1^k h \quad . \quad . \quad (8a)$$

The angles φ are, therefore, obtained by the successive summation of the versines h.

In equations (2) and (4) for the sections of abscissæ and of ordinates Δx and Δz the functions $\cos \varphi$ and $\sin \varphi$ appear. We can either calculate the angles φ *in degrees* by equation (8*a*) and then the values of Δx and Δz by equations (2) and (4), using trigonometrical tables, or else we can work with the angles φ in radians, in accordance with equation (8), afterwards substituting the functions $\cos \varphi$ and $\sin \varphi$ by the development of the cosines and sines in series. In this case it is possible to work it out on a slide-rule without recourse to trigonometrical tables. The two methods of calculation are shown in an example.

(b) **Calculation with trigonometrical tables.**

Example 1 :

Take, for example, a curve having a radius of 200 m. Let us suppose that for purposes of realignment the versines have been measured at every 10 metres with a chord 20 metres in length. The sides of the polygon have, therefore, a length $p = 1\,000$ cm. (It is recommended that for purposes of calculation the lengths be expressed in centimetres). It is required to prepare a plan of the curve to a scale of 1 : 500.

A table is prepared *(Table 1)* showing in the first column the numbers of the vertices of the polygon or the corresponding chainage in kilometres, and in the second the versines in centimetres, which are usually measured exactly to the nearest half-millimetre. The versines are added successively and the different values of Σh are entered in column 3, these figures being half a line lower than the versines in column 2. Then by

TABLE 1 *(relating to example 1).*

1	2	3	4	5	6	7	8
N°.	h	Σh	$\varphi^0 = 0\ 1146 \cdot \Sigma h$	$\Delta x = p \cdot \cos\varphi$	$x = \Sigma\ \Delta x$	$\Delta z = p \cdot \sin\varphi$	$z = \Sigma\ \Delta z$
	cm.	cm.	Measured in degrees.	cm.	cm.	cm.	cm.
0					0.0		
1	0.30	0.00	0° 0′ 0″	1 000.0	1 000.0	0.0	0.0
2	— 0.55	0.30	0° 2′ 0″	1 000.0	2 000.0	0.6	0.6
3	0.15	— 0.25	—0° 1′ 40″	1 000.0	3 000.0	— 0.5	0.1
4	0.70	— 0.10	—0° 0′ 40″	1 000.0	4 000.0	— 0 2	— 0.1
5	6.05	0.60	0° 4′ 0″	1 000.0	5 000.0	1.2	1.1
6	11.35	6.65	0° 45′ 40″	999.9	5 999.9	13.3	14.4
7	17.90	18.00	2° 3′ 40″	999.4	6 999.3	36.0	50.4
8	26.40	35.90	4° 6′ 40″	997.4	7 996 7	71.7	122.1
9	24.85	62.30	7° 8′ 20″	992.2	8 988.9	124.3	246.4
	etc.	87.15	9° 59′ 20″	984.8		173.5	

means of equation (8*a*) the angles φ are calculated from the values Σh. In the case under consideration $p = 1000$ cm. The angles φ measured in degrees are, therefore :

$$\varphi_o = \frac{180}{\pi} \cdot \frac{2}{1000} \cdot \Sigma h = 0.1146 \cdot \Sigma h.$$

Decimals of degrees are expressed in minutes and seconds, approximated to the nearest 20 seconds. Column 4 contains the angles φ° calculated in this way. The sections of abscissæ Δx are, from equation (2) :

$$\Delta x = p \cdot \cos\varphi = 1000 \cdot \cos\varphi.$$

As p has the round value of 1000, we can read off the values of Δx without any other calculation from a table of cosines and enter them in column 5. Their successive summation gives the required abscissæ x in column 6. In the same way, the sections of ordinates Δz and the ordinates z in columns 7 and 8 are obtained from equation (4), by means of a table of sines. After having plotted on paper to a scale of 1 : 500 the abscissæ x and the ordinates z the points thus obtained are joined up by means of a curved templet. This completes the work.

This method has certain complications as a result of the calculation of the angles φ in degrees, minutes and seconds by means of the sum of the versines in column 3. This conversion can be avoided if, instead of reading the versines in centimetres, a scale is used on which the angles ε can be read directly in *degrees*. Since the relation between the angles ε of the polygon and the corresponding versines h [equation (7)] depends on the length p of the side of the polygon, this scale is naturally only right for a given length p of polygon sides. It is advantageous to select a scale corresponding to $p = 1000$ cm. For angles ex-

pressed in minutes, we have from equation (7) :

$$\varepsilon' = \frac{180}{\pi} \cdot 60 \cdot \frac{2}{p} \cdot h \quad . \quad (7a)$$

which becomes, for $p = 1000$ cm. :

$$\varepsilon' = \frac{180}{\pi} \cdot 60 \cdot \frac{2}{1000} h = 6.8755\ h.$$

For an angle of the polygon $\varepsilon' = 1'$ the corresponding graduation on the scale shown in figure 6*b* is consequently :

$$h = \frac{1}{6.8755} = 0.1454 \text{ cm.} = 1.454 \text{ mm.}$$

Figure 6*b* shows this scale in comparison with the ordinary scale, graduated in centimetres as in figure 6*a*. The scales are arranged in such a way that it is also possible to read *negative* versines of up to 1 cm. (about 7 minutes) without changing over to the opposite side of the rail. Consequently, the string line used for measuring must be placed on two supports exactly at 1 cm. from the edge of the rail when the supports are placed against the rail.

With this scale, shown in figure 6*b*, the equipment used for measuring the versines becomes at once a *device for measuring the angles.*

Example 2 :

Take the same curve as in example 1. The measurements are entered up and used as in table 2. In column 1 are shown the numbers of the vertices as before, but in column 2, instead of the versines in centimetres, the angles ε are shown in degrees, read directly during measure-

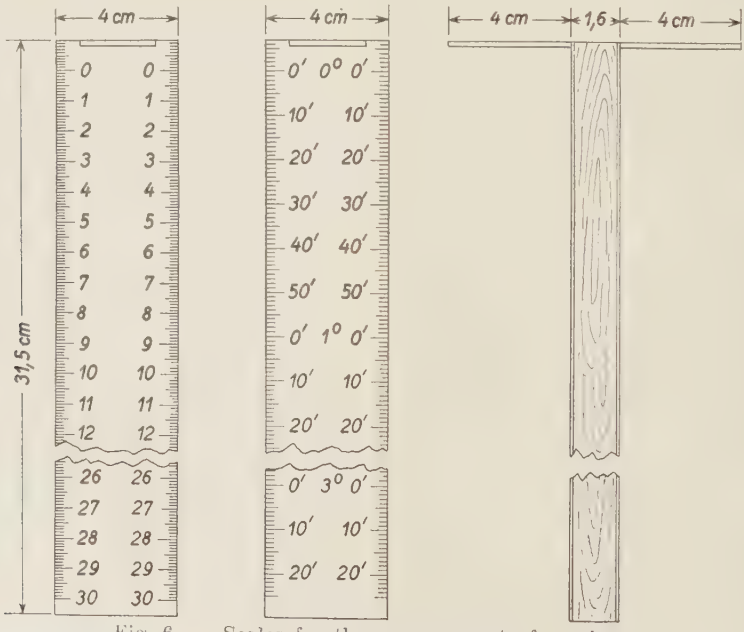


Fig. 6. — Scales for the measurement of versines.

(*a*) Scale graduated in centimetres.
(*b*) Scale graduated in degrees and minutes.
(*c*) Side view.

TABLE 2 *(relating to example 2).*

1	2	3	4	5	6	7
N°	ε^0	$\varphi^0 = \Sigma\varepsilon$	$\Delta x = p \cdot \cos\varphi$	$x = \Sigma\,\Delta x$	$\Delta z = p \cdot \sin\varphi$	$z = \Sigma\,\Delta z$
	Measured in degrees.	Measured in degrees.	cm.	cm.	cm.	cm.
0				0.0		0.0
1	0° 2′ 0″	0° 0′ 0″	1 000.0	1 000.0	0.0	0.0
2	— 0° 3′ 40″	0° 2′ 0″	1 000.0	2 000.0	0.6	0.6
3	0° 1′ 0″	— 0° 1′ 40″	1 000.0	3 000.0	— 0.5	0.1
4	0° 4′ 40″	— 0° 0′ 40″	1 000.0	4 000.0	— 0.2	— 0.1
5	0° 41′ 40″	0° 4′ 0″	1 000.0	5 000.0	1.2	1.1
6	1° 18′ 0″	0° 45′ 40″	999.9	5 999.9	13.3	14.4
7	2° 3′ 0″	2° 3′ 40″	999.4	6 999.3	36.0	50.4
8	3° 1′ 40″	4° 6′ 40″	997.4	7 996.7	71.7	122.1
9	2° 51′ 0″	7° 8′ 20″	992 2	8 988.9	124.3	246.4
	etc.	9° 59′ 20″	984.8		173.5	

ment with the scale shown in figure 6*b*. By successive summation the angles φ in column 3 are obtained, from which the abscissæ x and the ordinates z can again be calculated, as described above, by means of a table of cosines and sines.

All the calculation work consists, therefore, in summing up three columns of the table, viz. the measured angles ε of the polygon (col. 2), the sections of abscissæ Δx (col. 2) and the sections of ordinates Δz (col. 6). With this method, if we use the scale shown in figure 6*b* for the measurement of the versines, the work represented by the survey of a curve is reduced to a minimum.

(c) Calculation without the use of trigonometrical tables.

To avoid calculations with trigonometrical functions we will make use of the development in series of $\cos\varphi$ and $\sin\varphi$.

For our purpose we can be satisfied with the two first terms of these series :

$$\cos\varphi = 1 - \frac{\varphi^2}{2} \quad . \quad . \quad . \quad (9)$$

and

$$\sin\varphi = \varphi - \frac{\varphi^3}{6} \quad . \quad . \quad . \quad (10)$$

Equation (2) then becomes :

$$\Delta x_k = p \cdot \left[1 - \frac{(\varphi_{k-1})^2}{2} \cdots\right].$$

If we substitute for φ_{k-1} the value given by equation (8) it becomes :

$$\Delta x_k = p \cdot \left[1 - \frac{2}{p^2} \cdot (\sum_1^{k-1} h)^2\right]$$

or

$$\Delta x_k = p - \frac{2}{p} \cdot (\sum_1^{k-1} h)^2 \quad . \quad (11)$$

The successive summation of these sections of abscissæ Δx gives, by means of equation (3), the required abscissæ x.

Equation (4) is transformed in a similar way in order to obtain the sections of ordinates Δz. With the value of sin φ given by equation (10) we have :

$$\Delta z_k = p \cdot \left[\varphi_{k-1} - \frac{(\varphi_{k-1})^3}{6} \right].$$

If we substitute for φ_{k-1} the value given by equation (8), we get :

$$\Delta z_k = p \cdot \left[\frac{2}{p} \sum_1^{k-1} h - \frac{8}{6 \cdot p^3} \cdot \left(\sum_1^{k-1} h \right)^3 \right]$$

or

$$\Delta z_k = 2 \cdot \sum_1^{k-1} h - \frac{4}{3 \cdot p^2} \cdot \left(\sum_1^{k-1} h \right)^3 \quad (12)$$

For the practical application of this method it is recommended that the *semi*-sections of the ordinates :

$$\frac{\Delta z_k}{2} = \sum_1^{k-1} h - \frac{2}{3 \cdot p^2} \cdot \left(\sum_1^{k-1} h \right)^3 \quad (12a)$$

be first calculated.

The successive summation of these semi-sections of ordinates $\frac{\Delta z_k}{2}$ gives, by equation (5), the semi-ordinates $\frac{z}{2}$.

Before showing the calculation in an example, it is necessary to indicate how to proceed so that the approximations admitted in equations (9) and (10) for cos φ and sin φ do not have too detrimental an effect on the accuracy of the plan.

We have replaced functions cos φ and sin φ by the two first terms of their development in series. As a result, the equations (11) and (12) only give the abscissæ x and the ordinates z as an approximation of the exact mathematical values.

The values of x and z calculated in this manner differ the more from the exact mathematical values as the angles of inclination φ to the axes of the abscissæ become greater, or, which amounts to the same thing, as the sum of the versines Σh becomes greater. In all practical cases, however, these errors are small as long as

$$\left.\begin{array}{l} \varphi < 23^0 \\ \text{or} \\ \Sigma h < 0.2 \cdot p \end{array}\right\} \quad . \quad . \quad . \quad (13$$

For curves the radius of which is less or equal to 300 metres slightly greater values can be allowed, such as

$$\left.\begin{array}{l} \varphi < 27.5^0 \\ \text{or} \\ \Sigma h < 0.24 \cdot p \end{array}\right\} \quad . \quad . \quad . \quad (13a$$

Let us suppose, for instance, that this limiting value of the sum of the versines is reached between two adjoining points m and n. The calculation is, therefore, stopped at the abscissa x_n and the ordinate z_n. The produced straight line m-n is considered as a new axis of the abscissæ the origin of which is m. Starting from this point, we commence another calculation with the versine $h_m = 0$ and the sum of the versines $\Sigma h_m = 0$. This calculation gives the abscissæ and the ordinates of the following points, in relation to the new axis of abscissæ m/x.

Example 3 :

Let us take the same curve as in examples 1 and 2. The calculation is worked out as shown in table 3. The first three columns contain the numbers of the vertices, the versines h and the sums of the versines Σh in the same way as the three first columns of table 1. In order to ob

TABLE 3 (*relating to example 3*).

1	2	3	4	5	6	7	8	9	10
N°	h	Σh	$\frac{2}{p} \cdot (\Sigma h)^2 = \frac{(\Sigma h)^2}{500}$	$\Delta x = p - \frac{2}{p}(\Sigma h)^2 = 1\,000 - \text{col. } 4$	$x = \Sigma \Delta x$	$\frac{2}{3p^2}(\Sigma h)^3 = \frac{(\Sigma h)^3}{1\,500\,000}$	$\frac{\Delta z}{2} = \text{Col. } 3 - \text{Col. } 7$	$\frac{z}{2} = \Sigma \frac{\Delta z}{2}$	$z = 2 \cdot \frac{z}{2}$
	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
0				1 000.0		0 0	0.0		
1	0.30	0.00			1 000.0			0.0	0.0
		0.30	0.0	1 000.0	2 000.0	0.0	0.3	0.3	0.6
2	— 0.55	— 0.25	0.0	1 000.0	3 000.0	0.0	— 0.2	0.1	0 2
3	0.15	— 0.10	0.0	1 000.0	4 000.0	0.0	— 0.1	0.0	0.0
4	0.70	0.60	0.0	1 000.0	5 000.0	0.0	0.6	0.6	1.2
5	6.05	6.65	0 1	999.9	5 999.9	0.0	6.7	7.3	14.6
6	11.35	18.00	0.6	999.4	6 999.3	0.0	18.0	25.3	50.6
7	17.90	35.90	2.6	997.4	7 996.7	0.0	35.9	61.2	122.4
8	26.40	62.30	7.8	992.2	8 988.9	0.2	62 1	123.3	246.6
9	24.85	87.15	15 2	984.8	9 973.7	0.4	86.8	210.1	420.2
10	25.10	112.25	25.2	974.8	10 948.5	0.9	111.4	321.5	643.0
11	25.80	138.05	38.2	961.8	11 910.3	1.8	136.3	457.8	915.6
12	27.45	165.50	54.8	945.2	12 855.5	3.0	162.5	620.3	1 240.6
13	20.30	185.80	69.0	931.0	13 786.5	4.3	181.5	801.8	1 603.6
14	18.65	204.45	83.6	916.4	14 702.9	5.7	198.8	1 000.6	2 001.2
15	17 35	221.80	98.3	901.7	15 604.6	7.3	214.5	1 215.1	2 430.2
16									
15									
16	17.15	0.00	0.0	1 000.0	1 000.0	0.0	0.0	0.0	0.0
17	15.70	17.15	0.6	999.4	1 999.4	0.0	17.2	17.2	34.4
18	19.30	32.85	2.2	997.8	2 997.2	0.0	32.8	50.0	100.0
19	17.50	52.15	5.4	994.6	3 991.8	0.1	52.1	102.1	204.2
20	18.65	69.65	9.7	990.3	4 982.1	0.3	69.4	171.5	343.0
21	18.15	88.30	15.6	984.4	5 966.5	0.4	87.9	259.4	518.8
22	15.00	106 45	22.7	977.3	6 943.8	0.8	105.6	365.0	730.0
23	11.45	121.45	29 5	970.5	7 914.3	1.2	120.3	485.3	970.6
24	7.70	132.90	35.3	964.7	8 879.0	1.6	131.3	616.6	1 233.2
25	5.20	140.60	39.5	960.5	9 839.5	1.8	138.8	755.4	1 510.8
26	3.75	145.80	42.5	957.5	10 797.0	2.1	143.7	899.1	1 798.2
27	— 1.05	149.55	44.8	955.2	11 752.2	2.2	147.4	1 046.5	2 093.0
28	0.50	148.50	44.1	955.9	12 708.1	2.2	146 3	1 192.8	2 385.6
29		149.00	44.3	955.7	13 663.8	2.2	146.8	1 339.6	2 679.2

tain the values Δx of equation (11) we commence by calculating the values of $\frac{2}{p}(\Sigma h)^2$, which are, in this case where $p = 1000$ cm. :

$$\frac{2}{1000} \cdot (\Sigma h)^2 = \frac{1}{500} \cdot (\Sigma h)^2.$$

These values are entered in column 4. It is sufficient to indicate in column 4 and the following columns the lengths to the nearest millimetre. By subtracting the numbers of this column 4 from $p = 1000$ cm. [see equation (11)], we obtain the required sections of abscissæ Δx. These are inserted in column 5. By the successive summation of the values Δx, we obtain the abscissæ x in column 6.

In order to determine the values $\frac{\Delta z}{2}$ in equation (12*a*), we first calculate the values $\frac{2}{3 \cdot p^2}(\Sigma h)^3$, which in this case, for $p = 1000$ cm., are :

$$\frac{2}{3 \cdot 1000^2} \cdot (\Sigma h)^3 = \frac{(\Sigma h)^3}{1\,500\,000}$$

and transfer these values to column 7. By subtracting the numbers in this column 7 from the values Σh in column 3, we obtain the required half-sections of ordinates $\frac{\Delta z}{2}$. These are entered in column 8. By the successive summation of the values $\frac{\Delta z}{2}$, we obtain the half-ordinates $\frac{z}{2}$ in column 9. We have entered in column 10 the whole ordinates z, obtained by doubling the $\frac{z}{2}$ in column 9. Obviously column 10 can be dispensed with, in which case instead of the ordinates z, the ordinates $\frac{z}{2}$ are indicated on the plan to a *double scale*.

The calculation from table 3 is continued, as explained above, until we have obtained, for example, the sum of the versines :

$\Sigma h \approx 0.24 \cdot p = 0.24 \cdot 1000 = 240$ cm.

We then stop the calculation after vertex 15 has been reached with the sum of the versines $\Sigma h = 221.80$ cm. Considering the side of the polygon 15/16 as a new axis of the abscissæ, we resume the calculation at vertex 15 with $h_{15} = 0$ and $\Sigma h_{15} = 0$. At vertex 28 the measurement is finished. The last sum of versines is less than 240 cm. That is why in this case it was enough to interrupt the calculation only once at the side 15/16 of the polygon.

We can now draw the plan of the curve, starting from the two abscissæ 0/1 and 15/16 (fig. 7*a*). We first draw a straight line on which point No. 0 is indicated, and mark off on this line from this point, at a scale of 1 : 500, the lengths x from column 6. Setting up from these points perpendiculars to the abscissa, equal to the ordinates z in column 10 (or, alternatively, equal to the ordinates $\frac{z}{2}$ from column 9 to a double scale, 1 : 250), we obtain the points 1 to 16 of the curve. The produced straight line 15/16 is the new axis of the abscissæ. In order to determine it exactly we do not draw it in with a ruler applied at points 15 and 16, but preferably calculate its inclination to the original tangent (see fig. 4) :

$$\tan \varphi_{15} = \frac{\Delta z_{16}}{\Delta x_{16}} = \frac{214.5}{901.7} = 0.2379$$

and draw a straight line through point 15 or 16, having this slope. Starting from

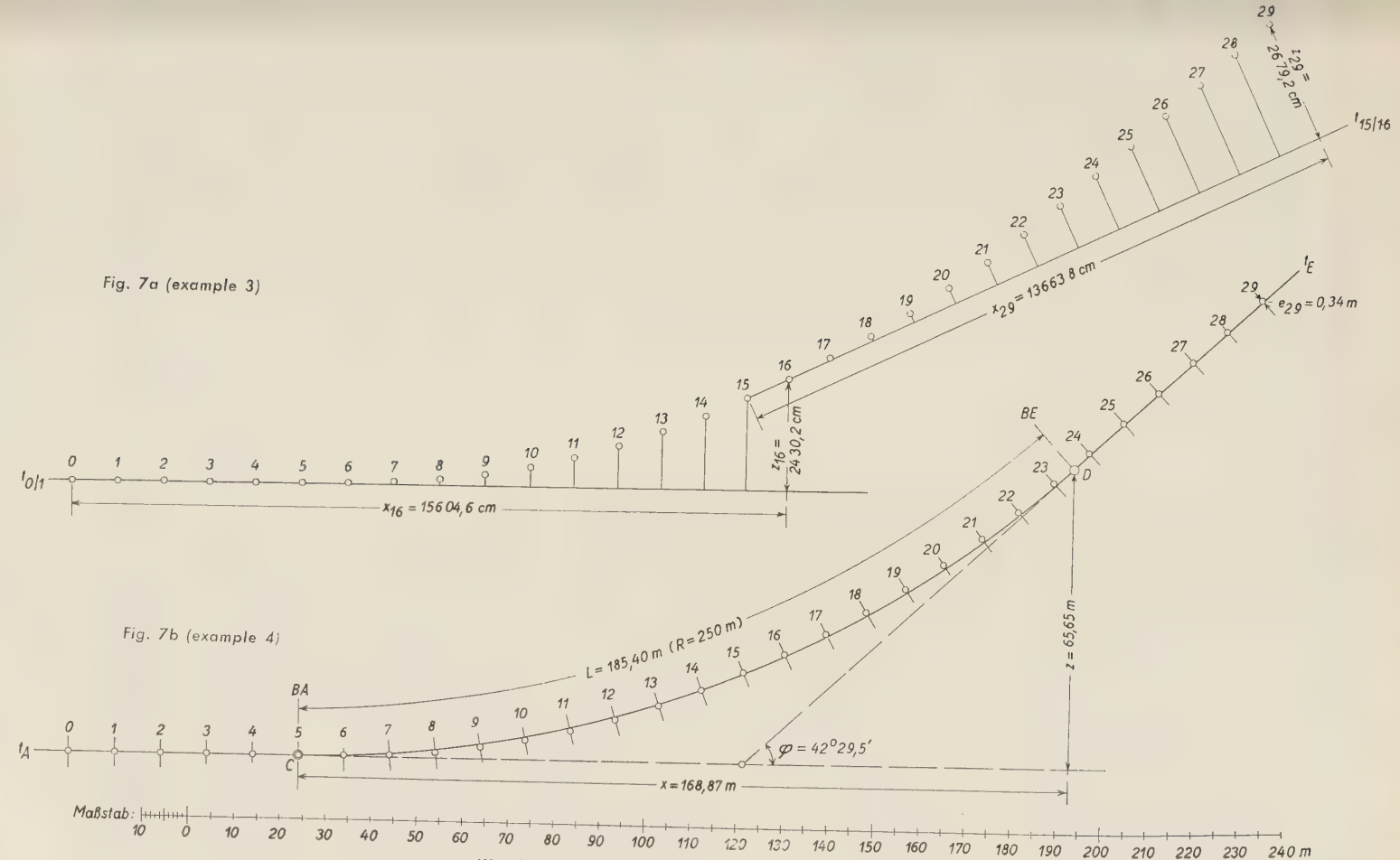


Fig. 7*a* (Example 3), and Fig. 7*b* (Example 4).

point 15 as the new origin, we plot abscissæ x from column 6 for vertices 17 to 29, then through the points thus obtained we draw afresh the ordinates z shown in column 10. In this manner we obtain the other vertices 17 to 29 of the curve. We can then, if required, join up the various points by means of a curved templet (fig. 7a). The plan of the curve is then finished.

3. — Graphical method.

This method is in some ways the reverse of the *angles diagram* method, which consists of ascertaining graphically by means of the measured versines the distances e between the new curve which it is required to set out, and the existing curve, all to large scales (usually 1 : 5 or 1 : 10). The points of the new curve are obtained by setting off these distances e from the existing curve on lateral perpendiculars.

If then the new curve is drawn on paper to the desired scale and the measured distances e are set off to the same scale, a plan of the existing curve is obviously obtained.

The *angles diagram method* has already been explained in detail in this Bulletin (2). In the following example we refer several times to this articles by simply quoting the pages of the German, French and English editions of the years indicated in footnote (2).

Example 4 :

Let us take the same curve as in the preceding examples. Here again we commence by drawing up a table *(Table*

(2) *Bulletin of the Railway Congress*, German edition, September 1934, pp. 891 to 923; French edition, January 1935, p. 7; English edition, February 1935, p. 222.

TABLE 4 (*relating to example 4*).

1	2	3	4
P	h	$h_R = h - 12$	Σh_R
	cm.	cm.	cm.
0			0.00
1	0.30	— 11.70	— 11.70
2	— 0.55	— 12.55	— 24.25
3	0.15	— 11.85	— 36.10
4	0.70	— 11.30	— 47.40
5	6.05	— 5.95	— 53.35
6	11.35	— 0.65	— 54.00
7	17.90	5.90	— 48.10
8	26.40	14.40	— 33.70
9	24.85	12.85	— 20.85
10	25.10	13.10	— 7.75
11	25.80	13.80	6.05
12	27.45	15.45	21.50
13	20.30	8.30	29.80
14	18.65	6.65	36.45
15	17.35	5.35	41.80
16	17.15	5.15	46.95
17	15.70	3.70	50.65
18	19.30	7.30	57.95
19	17.50	5.50	63.45
20	18.65	6.65	70.10
21	18.15	6.15	76.25
22	15.00	3.00	79.25
23	11.45	— 0.55	78.70
24	7.70	— 4.30	74.40
25	5.20	— 6.80	67.60
26	3.75	— 8.25	59 35
27	— 1.05	— 13.05	46.30
n=28	0.50	— 11.50	34.80

$\sum_{1}^{28} h = 370.80$ centimetres.

No. 4). The surveying notebook used for the measurements is sufficient, as only a small number of columns is required. As before, we enter in columns 1 and 2 the numbers of the vertices and the measured versines h. Then we choose a « *scale of the versines* » c_h (see pp. 899, 15, 230 respectively). For *setting out curves*, we generally take $c_h = 1 : 2.5$ or $1 : 5$. The distances e from the new curve to the existing curve are then drawn to scales $1 : c_h = 1 : 5$ or $1 : 10$. If on the contrary it is only a matter of protracting a survey, smaller scales of versines, such as $c_h = 1 : 10$ or $1 : 20$ will suffice.

For convenience in calculation we will take in our case :

$$c_h = 1 : 10.$$

The *lateral scale* is, therefore :

$$c_b = \frac{2}{c_h} = \frac{2}{1 : 10} = 20.$$

Then we calculate the sum of all the $n = 28$ measured versines by adding up the figures in column 2, and we find $\sum_1^{28} h = 370.80$ cm. As we obtain the ordinates of the angles diagram by multiplying the sum of the versines by the scale of the versines, the final ordinate of the angles diagram is, therefore :

$$c_h \cdot \sum_1^{28} h = \frac{1}{10} \cdot 370.80 = 37.08 \text{ cm.}$$

If, in order to plot the angles diagram, we choose as the section of abscissa $\Delta x = 1$ cm. (that is, a « *longitudinal scale* » of $1 : 1000$), the angles diagram rises very quickly. It is advisable, therefore, to work in this case with « *reduced versines* » (see pp. 900, 16, 230). We will adopt as a « scale of reduction » $k = 12$ cm. and then enter in column 3 the reduced versines

$$h_k = h - k = h - 12.$$

At the beginning and end of the curve where the measured versines are less than 12 cm., the reduced versines are negative. We add successively the reduced versines having regard to their sign, and insert the various sums Σh_k in column 4.

For protracting the angles diagram we will now choose as the section of abscissa

$$\Delta x = 1 \text{ cm.}$$

This length represents in the angle diagram the side p of the polygon. The *longitudinal scale* is therefore :

$$c_x = \frac{\Delta x}{p} = 1 : 1000.$$

We then mark off with a pin on a sheet of millimetre squared paper the numbers in column 4 to the scale $c_h = 1 : 10$ as ordinates from a horizontal abscissa, placing them in accordance with the arrangement of the table, midway between the numbered points (fig. 8*a*). As we are dealing with a left-hand curve, the *positive* quantities are marked off *upwards* and the *negative* quantities, *downwards*. In this way we obtain the points shown in circles in figure 8*a*. These points represent the angles diagram of the existing curve. To make them plainer they can be joined up by straight lines. The angles diagram is terminated by the two « *end parallels* » which correspond to the tangents at the ends of the curve. As a result of reducing the versines, the end parallels show an inclination to the horizontal :

$$\tan \beta = \frac{c_h \cdot k}{\Delta x} = \frac{\frac{1}{10} \cdot 12}{1} = 1.2$$

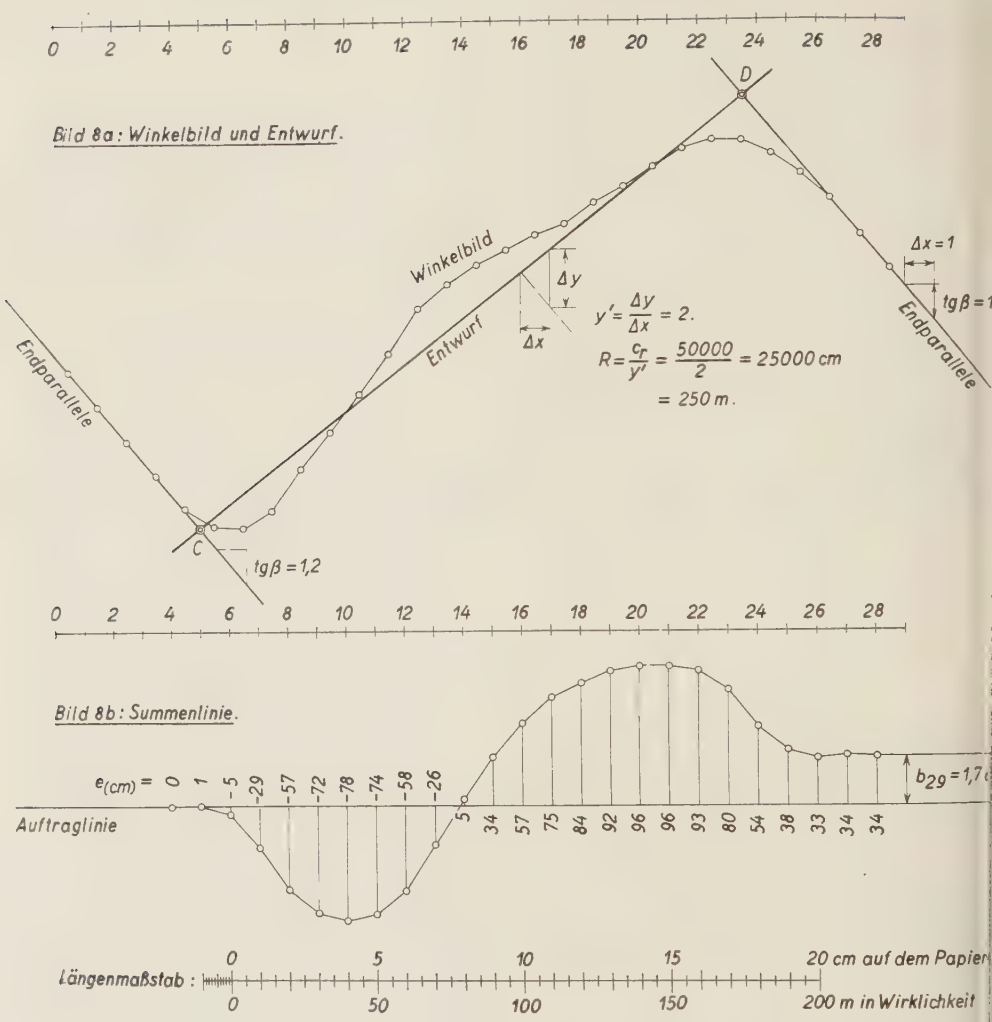

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Bild 8a: Winkelbild und Entwurf.
D
Winkelbild
Entwurf
Δy
Δx
y' = Δy/Δx = 2.
R = cr/y' = 50000/2 = 25000 cm
= 250 m.
Δx = 1
tgβ = 1
Endparallele
Endparallele
C
tgβ = 1,2
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Bild 8b: Summenlinie.
e(cm) = 0 1 -5 -29 -57 -72 -78 -74 -58 -26
5 34 57 75 84 92 96 96 93 80 54 38 33 34 34
b29 = 1,7
Auftraglinie
Längenmaßstab : 0 5 10 15 20 cm auf dem Papier
0 50 100 150 200 m in Wirklichkeit

Fig. 8*a* and 8*b* (Example 4).
Fig. 8*a* (top) : Angles diagram and scheme.
Fig. 8*b* (bottom) : Sum line.

Explanation of German terms :

Winkelbild = angles diagram. — Entwurf = scheme. — Endparallele = end parallels. — Auftraglinie = base line. — Längenmasstab = longitudinal scale. — auf dem Papier = on paper. — in Wirklichkeit = actually.

These are accurately fixed by drawing from the origin to the end of the angles diagram a straight line having this inclination tan β to the horizontal.

The curvature at any given point of the curve is proportional to the inclination $y' = \frac{\Delta y}{\Delta x}$ of the angles diagram to t

direction of the end parallels (see fig. 8*a*), and we have the equation :

$$R = \frac{c_r}{y'} \text{ (see p. 894, 10, 225).}$$

where c_r is the *curvature scale* :

$$c_r = \frac{p}{c_b \cdot c_x}$$

or in this case :

$$c_r = \frac{1000}{20\ (1 : 1000)} = 50\,000 \text{ cm.}$$

The equation of the radius of the curve (in centimetres) therefore becomes :

$$R_{(cm.)} = \frac{50\,000}{y'}$$

or in metres :

$$R_{(m.)} = \frac{500}{y'}.$$

The angles diagram (fig. 8*a*) rises at first fairly rapidly, and then after point 4, more slowly. It can be seen from this that the curve in question is a compound curve having radii between about 200 and 300 m.

For a trial curve intended to be used as a base line for drawing the new layout, it is only necessary to consider arcs of *even* radius, i.e., those which can be drawn with circular templets to the scale selected. It is preferable to take as a basis a single radius of projected curve. We first draw a provisional straight line which can be adapted more or less accurately to the angles diagram (not reproduced in fig. 8*a*).

From its slope y', we calculate, from the above equation, the corresponding radius. We find that it is approximately 250 m. To draw on a plan an arc of a circle having R = 250 m. to the scale 1 : 500 it is necessary to use a curved templet of radius $\frac{250}{500} = 0.5$ m.; this templet exists. Consequently, a suitable radius for this case is R = 250 m. In the angles diagram, a straight line corresponds to this radius, having an inclination y' to the direction of the *end parallels* :

$$y' = \frac{500}{R} = \frac{500}{250} = 2$$

or having an inclination to the horizontal of

$$y' - \tan \beta = 2.0 - 1.2 = 0.8.$$

We then draw on the trial plan a straight line having this inclination, in such a way that it coincides as much as possible with the angles diagram of the existing curve. It cuts the end parallels at points C and D. As the projected curve need not be set out, but only acts as a *base line* for drawing the plan, the difference between the outlines of the angles diagram and the new scheme is of no importance. Transition curves are not used as they would create needless difficulties in drawing the base line.

The differences of ordinates d between the angles diagram and the new scheme are added successively by means of dividers, and the different sums are entered as ordinates measured from a straight base line. We thus obtain the « sum line » (fig. 8*b*). In adding the differences of ordinates d, it is necessary to have regard to their signs. If the angles diagram of the existing curve lies *above* the new curve the differences d are *positive;* otherwise they are negative. In plotting the sums, the *positive* direction of ordinates is regarded as rising *from the bottom to the top.* The ordinates b of the

sum line give the distances e from the existing curve to the new curve by multiplying these ordinates, measured to the lateral scale, by c_b (in this case $c_b = 20$), in order to obtain the actual distances e. In figure 8*b*, the values of e are shown to the nearest centimetre. Where the value of e is positive (i.e. where the sum line lies above the base line) this indicates that at this place the projected curve lies to the *right* of the existing curve.

In order to obtain the points on the existing curve it is necessary, starting off from the trial curve, to draw the *positive* values of e to the *left* and the *negative* values of e to the *right*.

We can now draw the plan. It is first of all necessary to plot the new curve. The angle of the centre of the curve in radians is from equation 8 :

$$\varphi = \frac{2}{p} \cdot \sum_{1}^{23} h = \frac{2}{1000} \cdot 370.80 = 0\ 7416.$$

It follows that the length of the projected curve R = 250 m. is :

$$L = R \cdot \varphi = 250 \times 0.7416 = 185.4 \text{ m.}$$

We must draw to a scale of 1: 500 an arc of a circle of radius R = 250 m. and of length L = 185.4 m., with its end tangents on each side (fig. 7*b*). In order to be as accurate as possible, we will first of all fix the initial tangent at the origin C of the curve, and then calculate the abscissa x and the ordinate z of the end D of the curve in relation to this tangent :

$$x = R \cdot \sin \varphi . \quad . \quad . \quad (14)$$

$$z = R - R \cdot \cos \varphi . \quad . \quad (15)$$

In our example, the angle at the centre of the curve *in degrees* is

$$\varphi^0 = \frac{180}{\pi} \cdot \varphi = \frac{180}{\pi} \cdot 0.7416 =$$

$$= 42.491^0 = 42^0\ 29.5'.$$

From this we obtain $x = 168.87$ m. and $z = 65.65$ m. These co-ordinates determine the end D of the projected curve. We then join up C and D by means of a circular templet of radius R = 250 m., that is to say, at the scale we are using, i.e. 1 : 500 by means of a templet of 50 centimetres radius. In order to provide a still further check we can then calculate the length of the *chord* CD, either by means of the equation :

$$CD = 2 \cdot R \cdot \sin \frac{\varphi}{2} . \quad . \quad (16)$$

or by means of the equation :

$$CD = L - \frac{L^3}{24 \cdot R^2} + \frac{L^5}{1920 \cdot R^4} \quad (17)$$

This latter equation represents the development in series of the sines, and is considered sufficiently accurate for our use so long as $L < 1.4$ R. In our case we find CD = 181.18 m.

We then plot points 0 to 29 on the base line (i.e. the projected curve with its end tangents) and draw from these points at right angles to the base line short straight lines, on which we mark the distances e obtained from the sum line (fig. 8*b*), and thus obtain the required points on the proposed curve.

A graphical solution which differs from that described above is possible by means of the *method of relative di*

rams (3), but a study of this method ould go far beyond the scope of the resent article.

. — Comparison of the method by alculation and the graphical process.

By copying the plan (fig. 7*a*), obtained y calculation, on a sheet of tracing pa- er, and by placing it over the plan (fig. *b*) obtained by graphical means, we ind — assuming that the work has been arefully done — that the two plans coin- ide . An examination of the accuracy of ne two methods would be too lengthy o be dealt with here. Articles on this ubject have moreover already been pu- lished by Mr. CHAPPELLET (see foot- ote 1). We will be content, therefore, o state the following conclusion :

If properly applied, the method by cal- ulation, as well as the graphical method, ive very accurate results, on which the methods previously in use (setting out a special polygonal layout and measuring the angles with a theodolite) cannot improve. Moreover, with the methods considered above, the work is generally completed much more rapidly.

Preference for the method by calculation or the graphical method is a question which remains generally undecided, but it depends partly on the preference of the draughtsman for solution by calculation or by graphical means, and on his experience of the angles diagram method. If, for the purpose of *setting out*, a drawing of the angles diagram of the proposed curve is necessary in any case, the work involved in the graphical method is already more than half done, and this method is then always quicker. If, on the other hand, setting out is not required in the first instance, but only a survey, the method described in example 2 is the simpler. It is true that in this case the scale shown in figure 6*b* is needed for the measurement of the versines which scale enables the angles of the polygon to be read directly in degrees and minutes.

(3) SMODITZ : « Absteckung und Berichti- ung von Gleisbogen » (Setting out and re- ignment of curved track). *(Organ für e Fortschritte des Eisenbahnwesens)*, 1935 331.

[625. 14 (01 & 625. 144.2]

Track laying on curves for high speeds,

by FELICE CORINI,
Professor at the Royal University of Genoa,
Manager of the « Istituto di costruzioni stradali e ferroviarie.

(4th NOTE.)

I. — Introduction.

In the three notes published on this subject in April 1936 (1) we studied the behaviour of track laid on the straight under the action of important variations in temperature. We determined the maximum distance between the joints to be employed with the type of superstructure at present in use on main lines, by simply adopting the laying conditions recommended : temperature during laying, gap between the ends of adjoining rails fixed in accordance with the calculations given, and the assembling of the rails themselves in order to ensure rigidity. Finally, we examined the laying conditions (for a given temperature) and the anchorage of the superstructure to the ground in such a way that no transverse deformation of the track occurs, even with the highest temperatures, joints being dispensed with as the rails are welded. As already stated in the notes referred to above, in order to consider this question in all its aspects, we have still to study similar problems for curved track and to determine the influence of abnormal stresses in rails caused by the rolling stock, principally on curves.

Before going any further, however, w think it advisable to say a few word about the various communications whic have reached us from different source: some sent to us personally and other published in the technical press. Amon the more important, special mentio must be made of those from Mr. Robe Lévi, Chief Permanent Way Engineer o the French State Railways, and Dr. Bäs LER, Chief of the German State Railway Experimental Institute; among the letter published we would also mention tha from Mr. E. BATICLE, Chief of the Rail way Working Section at the Ministry o Public Works, France, which appeare in the September 1936 *Bulletin of th Railway Congress*. This question wa also made the subject of an article pu blished by Professor INADA of the Uni versity of Fukuoka (Japan). Engineer such as Messrs. Lévi and Bäseler, (wit whom we have also discussed the matte verbally) have told us about the investig ations they and their colleagues hav made in their respective countries. I the main they agree with us in refutin the theory of the proportionality be tween the transverse resistance of th ballast and the displacement of the track maintained by Mr. BATICLE and othe authors.

Mr. LÉVI agrees with the results w have obtained, viz. that the deformatio

(1) Cf. « Track laying for high speeds », by the same author, *Bulletin of the Railway Congress Association*, April 1936, page 317.

of the track is more easily produced in the horizontal plane; he explains in this way the fact that, in practice, there is always deformation in the horizontal plane, and remarks that every deformation of this kind is always the result of forcing up of the rails (1), which by nullifying the resistance of the ballast to transverse displacements makes it easier for deformations to occur in the horizontal plane. This is an ingenious explanation, which agrees with a theory put forward in Germany on the occasion of a recent important enquiry, but is not borne out by experience, as has been confirmed by Dr. Bäseler.

The latter gentleman agrees with us on the possibility of calculating the moment of inertia in relation to the vertical centre line of the track by means of the formula : $I = 2S\left(\frac{s}{2}\right)^2$, *at least as regards the order of magnitude,* when proper steps are taken to ensure the relative rigidity of the two rails.

One of the methods adopted to obtain nearly complete rigidity is to use the fastening of the Bäseler-Dietrich type for fixing the rails to the sleepers. The experiments which Mr. Bäseler has carried out on sections of track fitted in accordance with this system have led to the determination of a value of I of exactly 100 000 cm⁴ (2 400 in⁴.) Another method of obtaining quasi-rigidity between the rails is to use the American elastic fastening. Finally complete rigidity can be secured by joining the two rails by two diagonal bars which turn the track into a framed girder placed in a horizontal plane.

In a further Note we will publish particulars of experiments on this system specially devised for curved track.

In the letter referred to above, published in this *Bulletin*, Mr. Baticle, while approving without reserve our suggestions for anchorage to the ground, criticises the adoption of a frictional resistance to compensate the transverse displacement, thereby standing up for his own theory which we disputed. It also appears to him to be hazardous to adopt for the transverse moment of inertia of the track the value $2S\left(\frac{s}{2}\right)^2$. If no arrangements are made for increasing the relative rigidity of the two rails, we agree with this point; but the application of this formula presupposes the use of some arrangement of this kind.

A few words will suffice to meet the first observation : we do not dispute, on the contrary we admit that the ballast is an elastic medium, but it is so for vertical deformations, as its displacements in this direction are hindered by the ground which must in its turn be considered as an elastic medium. It cannot be considered in the same way in the transverse sense, as in this direction the whole mass moves instead of subsiding. If it were enclosed in *small longitudinal walls* (as may perhaps be found on certain lines), and if it were well compressed, Mr. Baticle's theory would be justified, although the limited expansion of the surfaces of the sleeper heads in contact with the ballast, instead of causing elastic compression, would lead to movements of the ballast elements, which would pile up in the spaces between the sleepers.

(1) Cf. R. Lévy : Les déplacements longitudinaux des rails et les déformations de la voie *(Longitudinal displacement of rails and deformation of track).* — *Le Génie Civil.* August 1932.

Mr. BATICLE's reasoning, based on the fact that there is no friction if there is no relative movement between the two surfaces in contact, definitely opposes his own hypothesis. As a matter of fact, if it is true that there is no friction if there is no relative slipping, it is no less true that when there exist conditions *which tend to produce a certain amount of movement between two surfaces in contact, a potential friction occurs which opposes this tendency.* For, what is *adhesion,* but a potential friction? The substitution of friction for adhesion as resistance to transverse displacement is only a concession in favour of safety. Inversely, if it is admitted that there is transverse resistance in proportion to the displacement, and, if such displacement is to be prevented, it means nullifying this resistance. To admit infinitely small movements would not only be contrary to the idea of « upsetting the equilibrium » by peak loads, which gives rise immediately to large deformations, but would bring us back to the point of admitting very small and consequently practicalli negligible resistances. What we have just said shows that our hypothesis not only corresponds to actual conditions, but is the only plausible one in practice. This opinion is also held by Mr. MARTINET, of the P.L.M. [1].

Having thus cleared the ground, we will continue our investigations and deal with the other questions raised.

II. — Maximum length of rails on a curve.

In order that the present study may follow the same lines as that dealing with straight track, we must first of all determine the part CD = $2x$ = L of the track AB, in a curve of radius R, which is not subject to displacement when the temperature rises from t_0 to t_1, and then study the section CD properly joined so that its ends cannot be displaced by a rise in temperature.

Now, we have seen in the case of straight track, that $2x$ is normally equal to 0, even for the longest permissible rail. As a result, in practice the interesting problem, when joints are not dispensed with, is that which concerns a length $2l$ of track stressed by the forces set up between adjoining rails by the portion of the expansion $\lambda_B - \delta$ which cannot occur because the gap 2δ between the rails is less than the expansion $2\lambda_B$ the rail would undergo if it were not enclosed in limited free spaces.

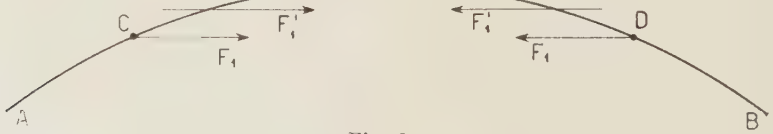


Fig. 1.

[1] The article : « Flambement des rails sans joints sur ballast et rails de grande longueur » *(Buckling of rails without joints on ballast and very long rails)* was published in the *Revue générale des Chemins de fer*, October 1936, after the present note had been written. Our previous notes and experiments are quoted therein.

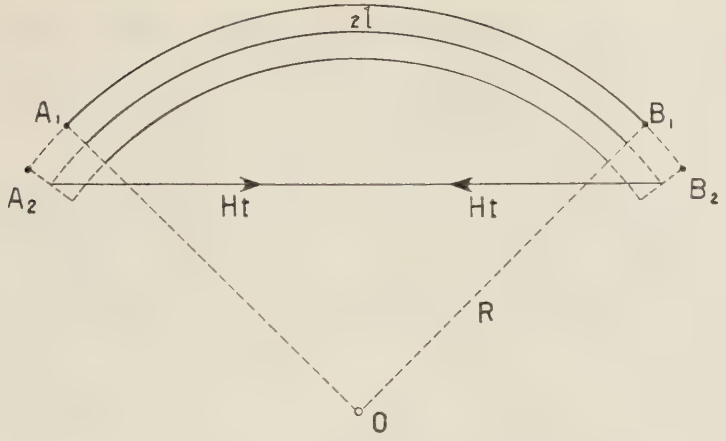


Fig. 2.

If the equation

$$2\,l\alpha\,(t_1 - t_0) = 2\,\delta \quad . \quad . \quad (1)$$

is complied with, the temperature at which adjoining rails come into contact is given by

$$t_1 = t_0 + \frac{\delta}{\alpha l} \quad . \quad . \quad . \quad (2)$$

For further increases in temperature

$$t - t_1,$$

any further displacement of the ends A_2 and B_2 of the track is impossible. As a result, the track is stressed by such forces as produce an equal elastic displacement opposed to the thermal displacement which would occur in free track. In order to determine the nature of these forces it is necessary to specify the type of fittings used in the track. The ends of the rails are joined by fishplates and bolts; it is logical to admit that there can

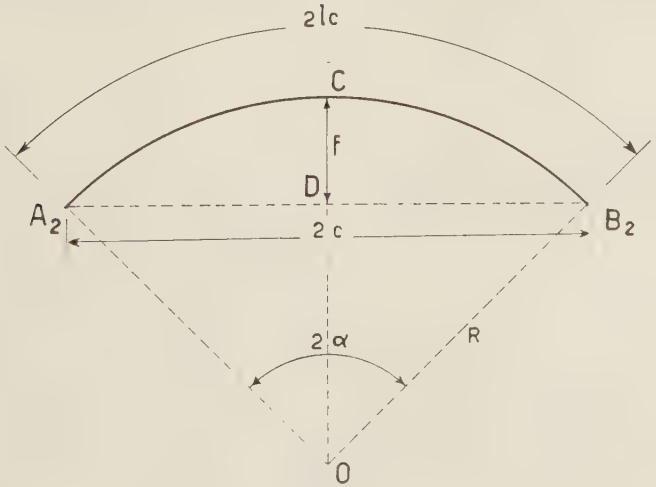


Fig. 3.

be nearly free rotation around the axes of the sections in contact.

In this case we can compare curved track of a length $2l$ to an articulated arc hinged at the ends. In another chapter we shall see how welded rails lead to the assumption of fixed ends. Consequently, in the case under review the reactions of the fastenings are two equal and contrary forces applied to the points A_2 and B_2 following the connecting line A_2B_2 and of a value H_t, such as :

$$H_t \cdot I = I\alpha\ (t - t_1) \cdot 2c \quad . \quad (3)$$

in which $2c$ is the chord A_2B_2 and I the moment of inertia of the elastic weight of the arc in relation to A_2B_2. We can consider the arc A_2B_2 by approximation as a parabolic arc of $2c$ chord and versine f. If 2α is the angle at the centre, we get :

$$\alpha = \frac{l}{R} \text{ in radians} \quad . \quad . \quad . \quad (4)$$

and

$$\left.\begin{aligned} f &= R\left(1 - \cos\frac{l}{R}\right) \\ 2c &= 2R \sin\frac{l}{R} \end{aligned}\right\} \quad . \quad . \quad (5)$$

In this hypothesis, using Ritter's well-known approximations for a very flattened parabolic arc, the thermal thrust will be :

$$H_t = \frac{3}{2} \cdot \frac{E I_0 \alpha\ (t - t_1)}{f.\ m} \quad . \quad . \quad (6)$$

in which m is the distance of the centre of gravity of the elastic weight of the second order of the chord and I_0 is the moment of inertia of the track in relation to the vertical centre line of the track itself. We have already admitted that :

$$I_0 = 2S\left(\frac{s}{2}\right)^2 \quad . \quad . \quad . \quad (7)$$

in which S is the area of the cross section of the rail and s the gauge. Further :

$$m = \frac{4}{5} f + \frac{3}{2} \frac{\rho^2}{f} \quad . \quad . \quad (8)$$

for

$$\rho^2 = \frac{I_0}{2s} = \left(\frac{s}{2}\right)^2 \quad . \quad . \quad (9)$$

If f is very small, the first term of the second member of (8) can be omitted and (6) becomes :

$$H_t = 2\ E.S.\ \alpha\ (t - t_1) \quad . \quad (10)$$

as in the case of straight track. Let us take A as the origin, AB being the axis of the x'es; let us compare the arc of circle ACB to a parabolic arc : $y = ax^2 + bx + c$ passing through the points A (0, 0), B $(2c, 0)$ and C (c, f). The coefficients being determined, we get :

$$y = -\frac{f}{c^2} x^2 + 2\frac{f}{c} x \quad . \quad (11)$$

A section S at the distance x from A is stressed by the force H_t, having the lever arm $y + r_i$, taking r_i as the displacement of the section in the transverse direction, and by the forces $2r'_2 \cdot d\xi$ operating with variable arms x-ξ; $2r'_2$ has the significance indicated in the previous notes, i.e. represents the resistance opposed by the ballast to the transverse displacement of the superstructure per unit of length, estimated this time in the perpendicular direction to the chord.

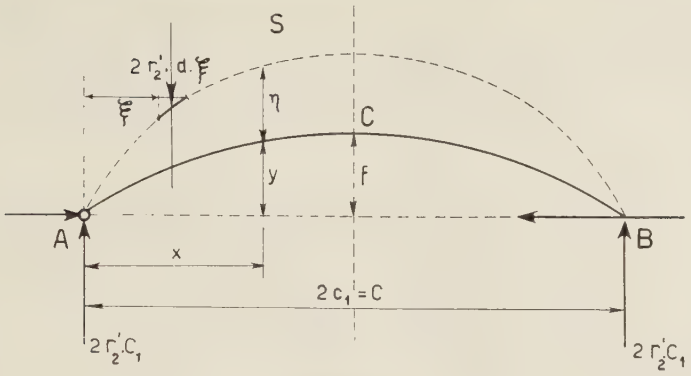


Fig. 4.

The moment of H_t is given by $H_t\,(y + \eta)$ and the moment of the distributed forces by :

$$2\,r'_2\,c \cdot x - \int_0^x 2r'_2\,(x - \xi)\,d\xi = + r'_2\,x\,(2\,c - x).$$

The equation of the elastic curve is given by :

$$- EI\,\frac{d^2\,(y + \eta)}{dx^2} = H_t\,(y + \eta) + r'_2\,x\,(2\,c - x) \quad . \quad . \quad . \quad . \quad (12)$$

Substituting for y the value given by (11) we get :

$$- EI\,\frac{d^2\eta}{dx^2} + \frac{d}{dx^2}\left(\frac{f}{c^2}\,x^2 - 2\,\frac{f}{c}\,x\right) = H_t\,\eta - \frac{f\,H}{c^2}\,x^2 + \frac{2\,f\,H}{c}\,x - r'_2\,x\,(2\,c - x) = M$$

or

$$- EI\,\frac{d^2\eta}{dx^2} + 2\,\frac{f}{c^2} = H\eta - \left(\frac{f\,H}{c^2} - r'_2\right)x^2 + 2\,c\left(\frac{f\,H}{c^2} - r'_2\right)x = M \quad . \quad (13)$$

Deriving twice relatively to x it works out :

$$- EI\,\frac{d^4\eta}{dx^4} = H\,\frac{d^2\eta}{dx^2} - 2\left(\frac{f\,H}{c^2} - r'_2\right) = \frac{d^2\,M}{dx^2} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

From (13) we get :

$$\frac{d^2\eta}{dx^2} = - \frac{1}{EI}\left(M - 2\,\frac{f}{c^2}\right);$$

and by substitution in (14), we have :

$$- \frac{H}{EI}\left(M - 2\,\frac{f}{c^2}\right) - 2\left(\frac{f\,H}{c^2} - r'_2\right) = \frac{d^2\,M}{dx^2}$$

or again

$$-\frac{H}{EI}M+2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]=\frac{d^2M}{dx^2} \quad . \quad . \quad . \quad . \quad (15$$

Let us take :

$$z=-2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]+\frac{H}{EI}M$$

$$\frac{d^2z}{dx^2}=\frac{H}{EI}\frac{d^2M}{dx^2} \quad \text{or} \quad \frac{d^2z}{dx^2}=-a^2z \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16$$

after having taken $a^2=\frac{H}{EI}$.

The general integral of (16) is

$$z=A\sin ax+B\cos ax \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16$$

or

$$-2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]+a^2\left[H\eta-\left(\frac{fH}{c^2}-r_2'\right)x^2+2c\left(\frac{fH}{c^2}-r_2'\right)\right]=A\sin ax+B\cos a$$

which gives

$$H\eta=\frac{1}{a^2}(A\sin ax+B\cos ax)+\frac{2}{a^2}\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]+\rho_1 x(2c-x) \quad . \quad (1$$

taking

$$\rho_1=\frac{-fH}{c^2}+r_2' \quad . \quad . \quad . \quad (\alpha)$$

Let us determine A and B so as to have :

for $x=0$ $\quad \eta=0$

for $x=c$ $\quad \frac{d\eta}{dx}=0$

We get

$$B=-2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]$$

$$A=-2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right]\operatorname{tg}(ac$$

If we take

$$\rho_2=2\left[\frac{fH}{c^2}\left(\frac{1}{EI}-1\right)+r_2'\right] \quad . \quad ($$

equation (17) becomes :

$$H\eta=-\frac{\rho_2}{a^2}\left(\sin(ax)+\operatorname{tg}(ac)\cos(ax)\right)+\frac{\rho_2}{a^2}+\rho_1\cdot x(2c-x)$$

or

$$\eta=-\frac{\rho_2}{a^2H}\left(\frac{\cos(ac-ax)}{\cos ac}-1\right)+\rho_1 x\frac{2c-x}{H}.$$

The maximum displacement occurs with $x = c$, and, as a result :

$$\eta_{max} = -\frac{\rho_2}{a^2 H}\left(\frac{1}{\cos ac} - 1\right) + \rho_1 \frac{c^2}{H}$$

or again :

$$\eta_{max} = -\frac{\rho_2}{a^2 H}\left(\frac{1}{\cos ac} - 1\right) + \frac{2\,\rho_1 (2\,c)^2}{8\,H} \quad (18)$$

which is similar to formula (18) of the first Note.

So as to have no straight lengths, it is necessary above all that :

$$ac < \frac{\pi}{2}$$

and consequently :

$$2\,c < \frac{\pi}{a}$$

and from (5) :

$$2\,R \sin \frac{2\,l}{2\,R} < \frac{\pi}{a}$$

or

$$2\,l < 2\,R \arcsin\left(\frac{\pi}{2\,\pi}\sqrt{\frac{EI}{H}}\right) \quad (19)$$

If the angle is small (i.e. if the radius is very large in relation to l), equation (19) agrees with equation (19) of the first Note.

Further, it is necessary to have :

$$\frac{1}{a^2}\left(\frac{1}{\cos ac} - 1\right) \leqslant \frac{2\,\rho_1}{\rho_2}\,\frac{(2\,c)^2}{8} \quad (19')$$

a similar formula to that of the first Note with the difference that the factor $\frac{2\rho_1}{\rho_2}$ figures here in the second member.

From (α) and (β) moreover it results that :

$$\rho_2 > 2\,\rho_1 ;$$

besides :

$$\rho_2 - 2\,\rho_1 = 2\,\frac{f\,H}{c^2\,EI} = 2\,\frac{f}{c^2} \cdot a^2$$

and consequently :

$$\frac{2\,\rho_1}{\rho_2} = \frac{2\,\rho_1}{2\,\rho_1 + 2\,\frac{f}{c^2}\,a^2} = \frac{1}{1 + \frac{f\,a^2}{c^2\,\rho_1}} \quad (20)$$

Furthermore :

$$\rho_1 < r'_2.$$

The condition for equal values of r'_2 (19'), gives an appreciably stricter limitation for curved track than for straight track.

A fact has to be borne in mind here which does not occur with straight track; in the latter case we have supposed that the rails are laid at a given high temperature, the only restriction being that at the lowest temperature the stress shall not exceed 1 000 kgr. (2 200 lb.).

In the present case, on the contrary, possible deformations have to be taken into account, due to stresses resulting from a fall in temperature. The problem is analogous to that which we have just studied, with the difference that H must be replaced by —H. The integral of (16) instead of being (16') becomes :

$$z = Ae^{ax} + Be^{-ax}. \quad . \quad (21)$$

the characteristic equation having true roots.

Under the same conditions as previously :

$$x = 0\,;\ \eta_1 = 0$$

$$x = c\,;\ \frac{d\eta_1}{dx} = 0$$

we get :

$$\left.\begin{aligned} A &= -\frac{1}{2}\,(\rho_2 + 2\,a\,\rho_1\,c) \\ B &= \frac{1}{2}\,(2\,a\,\rho_1\,c - \rho_2) \end{aligned}\right\} \quad (22)$$

and, after all :

$$\eta_1 = \frac{1}{Ha^2}\left(Ae^{ax} + Be^{-ax}\right) + \rho_1 x\,(2c - x) + \frac{\rho_2}{a^2} \quad . \quad . \quad . \quad . \quad (23)$$

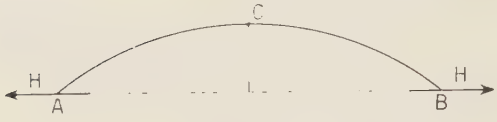


Fig. 5.

The condition of stability, *taking into account the character of the reaction of* r'_2 is expressed by assuming that :

$$(\eta)_{x=c} \leqslant 0 \quad . \quad . \quad . \quad (24)$$

Taking this formula as a basis and bearing in mind the maximum permissible unit stress for the minimum temperature, we can determine the laying temperature.

III. — Conditions of stability of curved track without joints.

Fig. 6.

Taking the section of curved track AB, let us assume *anchorage of the track* has been effected, as well on the straight as on curves, with a special anchorage at A and B. We can adopt the hypothesis that the resistance to transverse displacement is proportional to the displacement, and consider the arc as being rigidly fixed at A and B.

As in the preceding case, let us take as the equation of the arc AB the equation of the parabola having the same chord $2c$ and the same versine f. Equation (11) is therefore applicable.

In the present case of a fixed arc, the reaction of the connections due to the rise in temperature [assuming the laying temperature to be $t_m = 16°$ C. (60.8° F.)], it being understood that these connections are not liable to displacement, will be a force parallel to AB, through the elastic centre of gravity of the arc. In this case $GD = \frac{2}{3} f$.

$$H = \frac{45 \cdot \alpha \cdot (t' - t_m)\, EI_0}{4f^2 + 45\,\rho_2}. \quad (25)$$

wherein $\rho = \sqrt{\frac{I}{2S}}$ and the other letters have the meaning already indicated.

Let us consider a section S of abscissa x and ordinate y before the deformation. By reason of the supposed increase in temperature t'-t_m, it is subject to the displacement η_1.

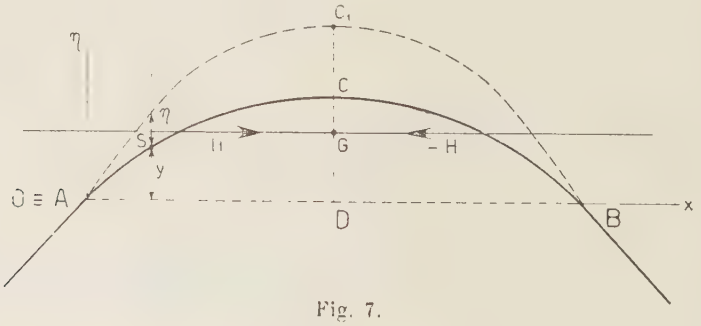


Fig. 7.

This section is stressed by the force H distant from the section :

$$(y + \eta) - \frac{2}{3} \mathrm{I},$$

and by the distributed forces

$$2\,\beta \cdot \eta \cdot d\xi$$

on the circular element : $ds = \rho\, d\xi$, 2β being the constant of proportionality.

The moment of H is :

$$\mathrm{H} \cdot (y + \eta - \frac{2}{3} f) ;$$

the moment due to the distributed forces is :

$$\beta \eta x\,(2\,c - x).$$

The equation of the elastic curve is given by :

$$-\,\mathrm{EI}\,\frac{d^2\,(\eta + y)}{dx^2} = \mathrm{H}\,(y + \eta - \frac{2}{3} f) + \beta \eta x\,(2\,c - x).$$

Substituting for y its value, and deriving twice, an equation of the type (25) of the first Note is obtained :

$$+\,\mathrm{EI}\,\frac{d^4\eta}{dx^4} + \mathrm{H}\,\frac{d^2\eta}{dx^2} + \beta\eta - \frac{f\mathrm{H}}{c^2} = 0 \quad (26)$$

The general integral of this differential equation is still of the type (26) of the first Note, but increased by the constant $\frac{f\mathrm{H}}{\beta c^2}$, that is :

$$\eta = \sum_0^\infty \mathrm{A}_n \sin\left(\frac{m\pi}{\mathrm{L}} x\right) + \frac{f\mathrm{H}}{\beta\, c^2}.$$

Relying on the same considerations as those developed in the first Note, it will be seen that there are no lateral inflections when

$$\mathrm{H} < 2\sqrt{\beta\,\mathrm{EI}} \quad . \quad . \quad . \quad (27)$$

It can be concluded therefrom that except for the difference between the value of H and that of F of the second Note [value depending on the radius of the curve as shown in (25)], it is possible to get a track that will not get deformed, even on a curve, by making the anchorage of the superstructure more effective. Even in this case the problem still exists of the possible deformation due to the flattening of the curve as a result of a fall in temperature. If the condition (27)

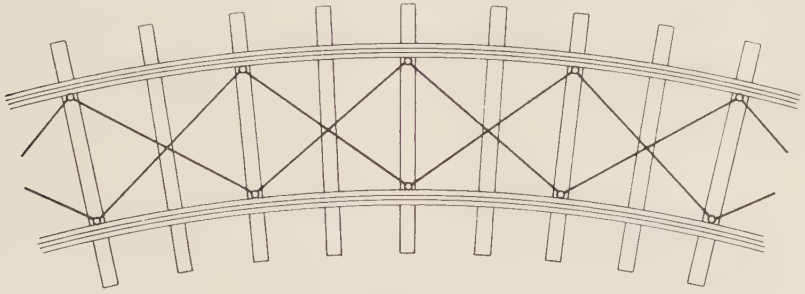


Fig. 8.

is fulfilled for the tension H produced by the fall in temperature, the deformation in question is also avoided.

As has been stated in the preamble, it is absolutely necessary in the case of *non-anchored* track to take precautions against deformation of the rail-sleeper system. With this object in view we think it is more than sufficient to join the sleepers diagonally; the superstructure is thus transformed into a frame girder (1).

In a further article we will consid the influence of stresses set up by t rolling stock in the track.

(1) Whatever arrangement is adopted, must be possible to insulate the rails electr ally in order to provide track circuits. F *anchored* curved track no precaution is nec sary.

[62 (01 & 621. 133.7]

The effect on locomotive boilers of pitting and corrosion,(*)

by J. L. CALLAHAN,
Service Engineer, National Aluminate Corporation.

(*Railway Mechanical Engineer.*)

A great deal has been written on the effect of alkalinity in boiler waters on corrosion. For the first time the results of a comprehensive series of experiments have been brought together for publication.

By alkalinity is meant the total carbonates and hydrates as obtained by titrating the water with an acid using methyl orange as the indicator. The prime purpose of adding alkalies to boiler feed water is to prevent the formation of hard scale so that most boiler waters carry alkalinity to some extent. Most feed waters have dissolved sulphates and chlorides, which concentrate in the boiler as dissolved salts. These salts together with the carbonates and hydrates and small amounts of other inorganic and organic matter constitute the dissolved solids. The dissolved solids are determined by evaporating a sample of boiler water and weighing the residue, or by using an electrical instrument.

There are several methods of expressing the alkalinity. The most common method is to state the total alkalinity as determined in the presence of the methyl orange indicator. Because of the difficulty of using methyl orange, other indicators are used. One of the easiest to use is phenolphtalein. However, this indicator will only show, in most cases, 85 to 95 % of the total alkalinity depending somewhat on the feed water used and the pressure. Others prefer to express the alkalinity as a percentage of the total dissolved solids. For example, if the total alkalinity was 20 and the total dissolved solids were 200, the per cent alkalinity would be 10.

Some excellent work has been done on corrosion, and one of the finest pieces of research was done by Commander Lyons for the Navy (**). His general conclusions were :

(1) small amounts of alkali slightly retard corrosion;

(2) increasing amounts increase corrosion until a maximum rate of corrosion takes place, and

(3) further additions of alkalies decrease corrosion until at high cencentrations of alkali no further corrosion takes place. Commander Lyons also found that all alkalies do not have the same effect.

With low chloride content he found that 50 grains per gallon of hydrated lime, 80 grains per gallon of soda ash, 61 grains per gallon of caustic soda, 110 grains per gallon of disodium phosphate, 13 grains per gallon of sodium chromate and 10 grains per gallon of sodium dichromate were required to stop corrosion. However, with more than 25 grains per gallon of sodium chloride present no amount of lime, chromates or dichromates would stop corrosion.

(*) Presented at the Convention of the Master Boiler Makers' Association held in Chicago, Wednesday, September 29, 1937.

(**) « Corrosion of Boilers and of Piping on Ship Board », by Commander Frank Lyons, *Journal of the American Society of Naval Engineers*, vol. 24, 1912, p. 845.

Commander Lyons also concluded that maximum corrosion occurred with 25 grains per gallon of soda ash or 19 grains per gallon of caustic soda, or 33 grains per gallon of disodium phosphate.

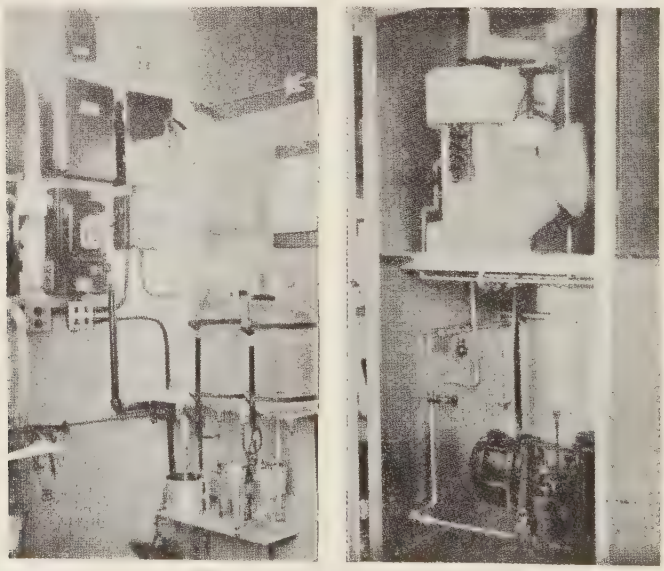
Experiences have differed on the effect of alkalinity. In many cases no corrosion or pitting has been experienced on railroads where alkalinities were maintained at a rather low value. In other cases railroads have had pitting at low and moderate alkalinities, and in some cases it has been found that excessively high alkalinities are required to prevent pitting. Because of these varied experience several series of experiments were conducted to find the effect of alkalinity.

The tests were made in boilers operating at 250 lb. per sq. in., using feedwater at the rate of 1 gallon per hour.

The experimental boilers hold 0.8 gallon at normal water level. Each consists of a vertical drum to which is attached the external heating section and return circulation tube. The heat is supplied by a suitable electrical heating element placed inside a boiler tube 12 in. long, which in turn is held securely inside the heating section.

A boiler tube can be withdrawn and inspected for scale and corrosion at the end of a test as the outside of the boiler tube is the water side, corresponding to a fire tube. The heating section and boiler tube are inclined upward from the bottom of the drum at an angle of 30° from horizontal. The circulation tube returns steam and water from the upper point of the heating section to the drum. By this means circulation of boiler water is obtained. The feedwater enters just below the waterline. Blowdown is taken 2 in. below the suface.

These boilers are operated by automatic devices which control the feedwater pumps, pressure, preheater temperature, blowdown rate, and evaporation rate at any setting desired.



Test apparatus. Right : Boiler and feed pump. Left : Feedwater storage and controls.

Left : Boiler tube ready for use.
Center : Surface of clean boiler tube.
Right : Tube corrosion with Alkalinity = 20. dissolved solids = 103.

The feedwater in all cases carried over 5 cm³ per liter of oxygen and was not preheated. In order to eliminate experimental errors while the boiler water was building up to cencentration, the tests were made on boiler water which was carefully preconcentrated to the desired value.

These tubes were made of standard 10-20 class A boiler-tube steel by welding a flange at one end and a plug in the other end, after which mill scale was removed by grinding with a final working of medium emery paper.

There are a great many factors which influence corrosion, but the purpose of this whole investigation was to find the effect of alkalinity alone when no other factors such as scale, organic matter, protected surfaces, or oxygen absorbents would interfere.

The first series of tests was made using a feedwater having the analysis of hardness = 0.0, total alkalinity = 3.2, chlorides = 4.3, sulphates = 8.5 and oxygen = 5.5 cm³ per liter. This feedwater was chosen as being similar to water where corrosion was being experienced. A feedwater alkalinity of 3.2 was used as this resulted in a boiler water having an alkalinity approximately 20 % of the dissolved solids.

Tests were made at ten different concentrations, with analyses and dissolved

TABLE I. — **First series of corrosion-research experiments.**

Boiler water analysis.						
H	P	M	Cl	SO^4	D.S.	Remarks.
.0	8.9	10.9	13.1	22	48	Considerable general corrosion and some pitting.
.0	18.0	20.0	28.0	54	103	Considerable general corrosion and pitting.
.0	33.0	36.0	44.0	83	161	Considerable general corrosion and some pitting.
.0	43.0	46.0	59.0	112	221	Considerable general corrosion and some pitting.
.0	53.0	57.0	83.0	164	318	Some general corrosion and some pitting.
.0	58.0	64.0	88.0	174	325	Some general corrosion and considerable pitting.
.0	67.0	69.0	100.0	193	371	Considerable general corrosion and pitting.
.0	73.0	81.0	110.0	203	406	Considerable general corrosion and some pitting.
.0	82.0	89.0	122.0	234	448	Some general corrosion and pitting.
.0	95.0	104.0	141.0	272	522	Some general corrosion and pitting.

Tube corrosion. Left : Alkalinity = 46, dissolved solids = 221. Center : Alkalinity = 104, dissolved solids = 522. Right : Alkalinity = 10.4, dissolved solids = 111.

solids varying between 48 and 522 grains per gallon, as given in table I, in order to cover as wide a range of conditions as possible.

The general conclusions of this series of tests are :

(1) that an alkalinity of 20 % of the dissolved solids does not prevent corrosion;

(2) that at low concentrations general red corrosion predominated, and

(3) that at high concentrations pitting predominated.

The question then arose as to whether or not any amount of alkalinity would stop corrosion. To answer this question a second series of nine experiments was made with feedwater analyses and total dissolved solids in the neighborhood of 135 grains per gallon, as given in table II, and with the amount of alkalinity in the boiler water varying between 5 and 90 grains per gallon. The feedwater analysis was chlorides = 4.3, sulphates = 8.5 and oxigen = 5.5 cm^3 per liter as in the previous series of tests, but in which the alkalinity was adjusted to get the desired alkalinity in the boiler water.

TABLE II. — **Second series of corrosion-research experiments.**

Boiler water analysis.						
H	P	M	Cl	CO^4	D.S.	Remarks.
0.0	3.1	5.1	49.9	91	155	Heavy general corrosion and pitting.
0.0	7.5	10.4	35.3	63	111	Considerable general corrosion and pitting.
0.0	17.3	20.9	31.2	60	119	Decrease in general corrosion, increase in pitting.
0.0	27.5	32.7	38.2	69	144	Decrease in general corrosion, increased pitting.
0.0	35.8	40.8	27.2	54	125	Further decrease in general corrosion, pitting greatly reduced.
0.0	49.9	54.0	26.0	57	134	Little general corrosion, some pitting.
0.0	64.0	71.0	20.5	42	139	Very little general corrosion or pitting.
0.0	77.0	85.0	17.0	36	143	No pitting.
0.0	83.0	90.0	17.0	29	140	No pitting.

The general conclusions from these xperiments are :

(1) that corrosion and pitting will be revented if sufficiently high alkalinity carried;

(2) that the addition of alkalinity nds to convert general red corrosion ito pitting, and

(3) that alkalinity will prevent gener- corrosion before it will prevent pitt- g.

With alkalinity of 85 and dissolved lids of 143 there was no corrosion or tting. Good results were also obtain- l with an alkalinity of 71 and dissolved lids of 139.

These two series of tests brought out a mber of interesting points, but it was lt that the investigation should be oadened to determine the amount of kalinity required over a wide range of nditions.

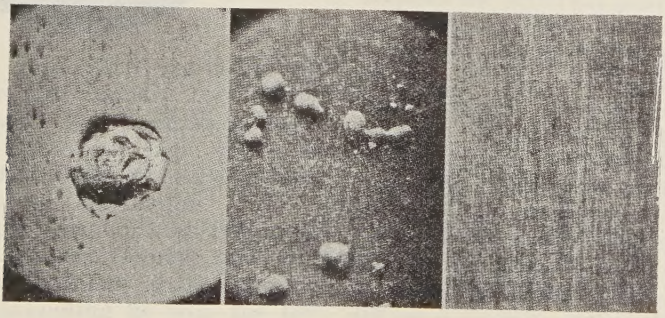
Further experiments were carried out uch in the same manner as the pre- ous experiments. The feedwater analy- s was chlorides = 4.3, sulphates = 8.5, id oxygen = 5.5 cm^3 per liter. In addi- on, sodium carbonate and caustic soda ere added in equal parts to maintain e desired alkalinity in the feedwater. This group of experiments consisted six series. In each series the amount chlorides and sulphates in the boiler water was held constant. The boiler water alkalinity was low in the first experiment of each series, and raised gradually with each succeeding experiment until more than enough alkalinity had been added to stop pitting. The results were consistent throughout, but each series of experiments was run twice in that portion considered to be the critical range, for complete protection.

One very interesting observation made was that in tests with low alkalinity the tubes were always red. As the alkalinity was increased the red corrosion gradually disappeared, the tube becoming darker and, in many cases, almost jet black. However, pitting persisted until sufficient alkalinity had been added. Those tubes on which corrosion could be found were covered with a jet-black film which was smooth and hard. This film was very thin and served to protect these tubes from atmospheric corrosion. This region is called the critical range.

The information obtained from the last experiments would justify the additional conclusions :

(1) that excessive alkalinity is required to be sure that corrosion does not take place;

(2) that as the dissolved solids increase the amount of alkalinity required increases, and



Tube corrosion. Left : Alkalinity = 20.9, dissolved solids = 119. Center : Alkalinity = 54, dissolved solids = 134. Right : Alkalinity = 71, dissolved solids = 139.

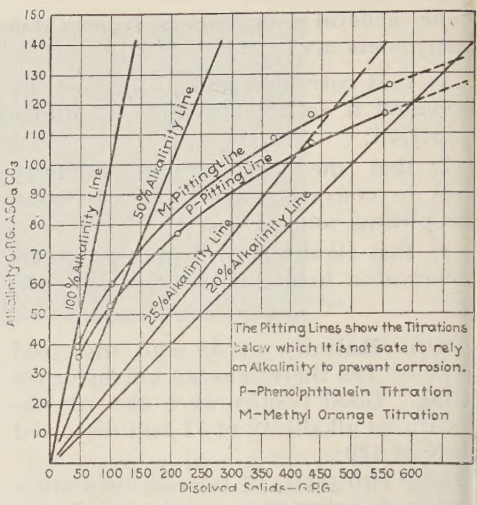
(3) that the percentage of alkalinity required is less with high dissolved solids than with low dissolved solids.

TABLE III. — **Conclusions of corrosion research experiments.**

Dissolved saline salts, grains per gallon.	Alkalinity, grains per gallon.	
	Corroding.	Non-corroding.
0	36	39
40	58	61
125	78	84
260	104	108
310	106	116
420	118	126

The general conclusions obtained from these investigations, as given in table III, agree with the findings of Commander Lyons, except that our observations do not justify the conclusion that there is a maximum corrosion rate at alkalinities of 19 to 25 grains per gallon.

This may be explained on the basis that our tests were made without scale-forming substances present, whereas with scale-forming substances present less corrosion is to be expected at low alkalinity where the tubes will be covered with scale than at higher alkalinities where the tubes will not be so well protected by scale.


Alkalinity G.P.G. As CaCO3
Dissolved Solids—G.P.G.
100% Alkalinity Line
50% Alkalinity Line
25% Alkalinity Line
20% Alkalinity Line
M-Pitting Line
P-Pitting Line
The Pitting Lines show the Titrations below which it is not safe to rely on Alkalinity to prevent corrosion.
P—Phenolphthalein Titration
M—Methyl Orange Titration

Alkalinity as a corrosion preventive.

Field observations have tended to substantiate the findings presented here.

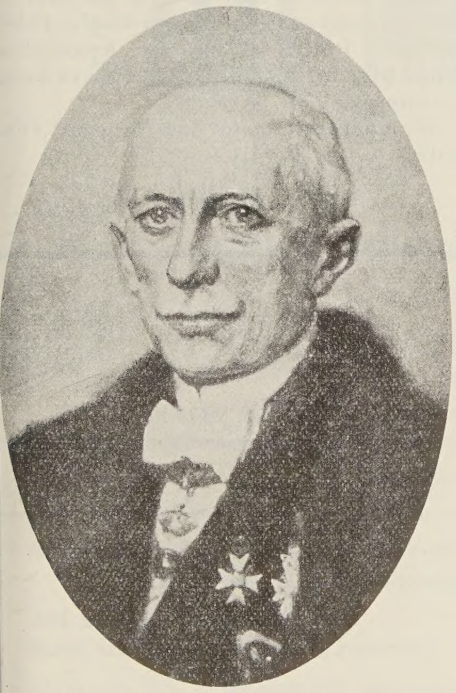
The author acknowledges the cooperation of Dr. P. G. Bird, Research Director of the National Aluminate Corporation, under whose direction these experiments were conducted.

[385 (0.92]

OBITUARY.

Henri CAUFRIEZ,

Late General Manager, National Light Railways Company (Belgium),
Member of the Permanent Commission of the International Railway Congress Association.



We heard with deep regret of the eath, on the 11th January last, of Mr. enry CAUFRIEZ, late General Manager the Belgian National Light Railways ompany and Member of the Permanent ommission of our Association.

Mr. CAUFRIEZ was born at Pâturages Hainaut) on the 23rd October 1869, and as a brilliant scholar; at the close of s classical schooling he won the Go- rnment Prize.

In 1891, at the University of Ghent, he as graduated an honorary civil engineer (bridges and highways), and in 1893, following a competitive examination, he was appointed an engineer of the Belgian State Railways.

Early in 1907, when he was acting divisional manager at Arlon, he became private secretary of Minister LIEBAERT. Mr. CAUFRIEZ subsequently was the principal private secretary of three successive Ministers of Railways, Marine, Posts, Telegraphs and Telephones.

On the 6th February 1913, he succeeded Mr. DE BURLET as General Manager of the Belgian National Light Railways Company.

During the twenty years he held this post, this Company met with many difficulties. It is hardly necessary to recall the disturbance caused by the occupation of the Country during the world war.

The question was not only to keep the Light Railways in operation as they were the only means of communication between the different provinces, but also to resist as much as possible the attempts to remove the track. As soon as the war was over, 1 550 miles of destroyed or damaged lines had to be reconditioned. Meanwhile, financial circumstances compelled the Companies to which the operation of the lines was leased to give up business, so that, besides its former task consisting in building the lines, the National Company had to work the whole system by itself and set up a suitable organisation. The position was the more intricate that, in the course of the next years, owing to the economic depressions, together with

the most severe competition from other methods of transport, the Public Authorities were unable to provide the money which was much needed in order to modernize the System.

Despite all these hindrances, when Mr. CAUFRIEZ left the National Light Railways Company in 1933, 750 miles of electrified lines were in operation, the working results of which enabled the Company to carry on its task of serving the least favoured districts of the country, where soon afterwards steam trains were to be gradually superseded by rail-cars.

Mr. CAUFRIEZ will be remembered as a righteous and very cautious man, endowed with a rare steadfastness of purpose, who always scrupulously placed duty first.

He was a Commander of the Order of Leopold, Grand Officer of the Order of the Crown of Belgium and of the Order of Leopold II, and was also the holder of many foreign honours.

Mr. CAUFRIEZ had been a Member of the Permanent Commission of the International Railway Congress Association from 1922 to 1933, and was always keenly interested in its work.

We wish to convey our sincerest sympathy to his family.

The Executive Committee.